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818

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CONTRACTING ENGINEERS.
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Second-hand ELECTRICALLY DRIVEN COMPRESSORS for pressures up to 2500 lbs. per sq. in MOTORS 60 to 100 HP. In perfect condition, at about one-third current prices.
Also DIESEL Engines to 1200 HP.
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Sole Licensees in Great Britain for the manufacture of "Armco" Rust and Corrosion Resisting Iron Tubes 817
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See Advertisement page 69.

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FEED WATER HEATERS, CALORIFIERS, EVAPORATORS, CONDENSERS, AIR HEATERS, STEAM AND GAS KETTLES, } ROW'S PATENTS.
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Tubes AND Fittings
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Steel Plates.
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See Advertisement Page 52. 9952

For Immediate Disposal,
GAS ENGINE PLANT comprising:—
One four-cylinder Tandem Westinghouse Gas Engine, 700 B.HP. at 300 revs.; direct coupled to "Vickers" D.C. Generator 440/500 volts with switchboard, etc.
One Suction Pressure Gas Producer (Ruston and Proctor), designed to operate on Welsh Anthracite or Coke.
The above were purchased in 1918, and are in new condition, and may be inspected at any time by appointment.
Full particulars may be obtained on application to
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THE GLASGOW ROLLING STOCK AND PLANT WORKS.
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Electric Cranes.
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Diesel & Steam
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819

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GENERAL CONSTRUCTIONAL ENGINEERS. 1316
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STILLS, PETROL TANKS, AIR RECEIVERS, STEEL CHIMNEYS, RIVETTED STEAM and VENTILATING PIPES, HOPPERS, SPECIAL WORK, REPAIRS OF ALL KINDS.

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LIMITED.
See Advertisement page 58, Dec. 29. 2402

See's Patent Hydro-Pneumatic Ash Ejector.
Great saving of labour. No noise. No dust. No dirt. Ashes discharged 20 ft. clear of vessel.—Apply, F. J. TREWENT & PROCTOR, LTD., Naval Architects and Surveyors, 43, Billiter Bldgs., Billiter St., London, E.C. Od 4835

Petter Oil Engines.
For Paraffin and Crude Oil.
Sizes 1½ B.HP. and upwards.
Petters Limited, Yeovil.
Sizes 25 to 800 B.HP.
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See advertisement alternate weeks. 9335

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T. SUMMERSON & SONS, LIMITED, DARLINGTON. 000

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WEIGHING MACHINES—EAST FERRY ROAD ENGINEERING WORKS COMPANY, LTD. LONDON, E.—Hydraulic Cranes, Grain Elevators, &c. See illus. Advt. last week, page 15. 991

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Centrifugals.
Pott, Cassels & Williamson,
MOTHERWELL, SCOTLAND.
939
See half-page Advertisement, page 38, Dec. 22.

The Manchester Steam Users' ASSOCIATION.

For the prevention of Steam Boiler Explosions and for the attainment of Economy in the Application of Steam. 9, MOUNT STREET, MANCHESTER.
Chief Engineer: C. E. STROMEYER, M.I.C.E.
Founded 1854 by SIR WILLIAM FAIRBAIRN.
Certificates of Safety issued under the Factory and Workshops Act, 1901. Compensation for Damages and Liabilities paid in case of Explosions. Engines and Boilers inspected during construction. 598

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AN ENGINEERING SCHOLARSHIP, provided by the South Wales Institute of Engineers, of the value of £70 per annum, tenable for three years by a student who intends to enter some branch of the Engineering Profession, will be OFFERED for COMPETITION at the College Entrance Scholarship Examination, which begins on April 16, 1923.
Further particulars can be obtained from the undersigned, to whom the form of application must be returned on or before March 19, 1923.
D. J. A. BROWN, Registrar.
University College, CARDIFF,
December 30, 1922. X 208

Correspondence Courses for

Inst. Civil Engrs., Inst. Mech. E., London Univ. (Matric., Inter., B.Sc.), and ALL ENGINEERING EXAMINATIONS personally conducted by Mr. TREVOR W. PHILLIPS, B.Sc. (Honours), Assoc. M.Inst.C.E., M.R.S.I., F.R.S.A., &c. Also Day Tuition in Office. Excellent results at all Exams. Courses may commence at any time, and all Students receive individual tuition.—For full particulars apply to 8/11, TRAFFORD CHAMBERS, 56, SOUTH JOHN STREET, LIVERPOOL. 575

Correspondence Courses for

INST. MECH. E. EXAMINATIONS. — Also Special Courses as follows: Works Organisation, Administration, Pneumatic Engineering, Crane Design, &c.—Address, W 927, Offices of ENGINEERING.

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Powering of Vessels. — A

Practical Course of Instruction by Correspondence.—Address, for particulars and terms, 1049, Offices of ENGINEERING.

TENDERS.

THE BURMA RAILWAYS COMPANY, LIMITED.

The Board of Directors of the Burma Railways Company, Limited, are prepared to receive

Tenders for the Supply of :—

(a) 4101 tons 13½ cwts. STEEL F.F. RAILS (B.S.) 60 lbs.
(b) 13,230 pairs STEEL FISHPLATES for B.S. 60 lbs. f.f. Rails.
(c) 196,000 DOG SPIKES (W.J.) for f.f. rails, (B.S.) 60 lbs. and N.S. 50 lbs.

Fees for the Specifications, which are not returnable, will be charged as follows :—
For each copy of Specification (a)...20s.
" " " " " (b)...10s.
" " " " " (c)... 5s.
Tenders, enclosed in sealed envelopes, endorsed "Tender for Steel Rails," or as the case may be, must be delivered at the Company's Offices not later than TWELVE noon on Thursday, 11th January, 1923. The Directors do not bind themselves to accept any or the lowest Tender, and reserve the right to divide the order.
Early delivery is important.
By order of the Board,
F. C. FRANKS, Secretary.
129, Gresham House, Old Broad Street, London, E.C. 2.
3rd January, 1923. X 235

CITY OF MANCHESTER.

PLANT FOR SALE.

The ELECTRICITY DEPARTMENT have

For Disposal the Following

PLANT :—
One 1800 Kw. D.C. Parsons Turbo-Generator, 400/480 volts
Six Lancashire Boilers, with Vicars mechanical stokers.
Four Babcock & Wilcox Boilers, each 10,000 lbs. per hour, with Vicars and Bennis mechanical stokers,
Two Green's Economisers.
Two Blake & Knowles' Boiler Feed Pumps.
All the necessary steam and water pipes, valves etc.
Working pressure for all the above steam plant—130 lbs. per square inch.
One Wrigley's screw Coal Conveyor.
Four 440 Volt D.C. Motors (three 10 HP., and one 5 HP.) by well-known makers, complete with stoker shafting.
One Parker's 2½ ton Electrical Jib Crane.
The above plant is in working order and may be inspected by appointment.
Form of Tender and the Conditions of Sale may be had on application to Mr. F. E. Hughes, Secretary, Electricity Department, Town Hall, Manchester.
Further particulars relating to the plant or to the Conditions of Sale may be obtained from Mr. S. L. Pearce, Chief Engineer and Manager, Dickinson Street, Manchester.
Tenders, duly endorsed and addressed to the Chairman of the Electricity Committee, must be delivered at the Town Hall not later than Ten o'clock a.m. on MONDAY, the 22nd JANUARY, 1923.
P. M. HEATH, Town Clerk.
Town Hall, Manchester,
30th December, 1922. X 217

HIGH CARLBY SANATORIUM, near ULVERSTON.

FOR SALE, VERTICAL BOILER.

Offers are Required for a

Vertical BOILER, size 10 ft. 6 in. by 3ft. 6 in., working pressure insured at 40 lbs. to sq. inch.
It will be necessary to take down a portion of two walls in order to admit of the removal of the boiler, and any offers should include the taking down and reinstatement of the brickwork, etc. The boiler can be seen on application to the Medical Superintendent.—Offers to be sent in to Dr. G. LISSANT COX, Central Tuberculosis Officer, County Offices, Preston. X 242

TYNE IMPROVEMENT COMMISSION.

ELECTRIC MOTORS.

The Tyne Improvement Commissioners are prepared to receive

Tenders for the Supply of One

20 HP. and Three 3 HP. D.C. ELECTRIC MOTORS.
Copies of the Form of Tender and Specification may be obtained on application from the undersigned.
Tenders in sealed envelopes, endorsed on the cover "Tender for Electric Motors and Accessories," must be addressed to the undersigned and delivered to him not later than the 18th day of January, 1923.
The Commissioners do not bind themselves to accept the lowest or any Tender.
By Order,
RICHARD AUGHTON, General Manager.
Tyne Improvement Commission Offices, Bewick Street, Newcastle-on-Tyne.
4th January, 1923. X 238

STATE ELECTRICITY COMMISSION OF VICTORIA.

TENDERS FOR PLANT.

Tenders are Hereby

Invited for the SUPPLY, DELIVERY, etc., of the following for Morwell Power Scheme.
Copies of Tender Form and Specification may be obtained or inspected upon application to :—
AGENT-GENERAL FOR VICTORIA, Melbourne Place, Strand, London, W.C. 2.
SPECIFICATION No. 23/8—
TRANSFORMERS.
CHARGE :—5s. for first two copies of Tender Form, Conditions of Contract, and Specification complete. This charge will be returned on receipt of a *bona fide* Tender. A third, or any further copies may be obtained on payment of 2s. 6d. per copy, not returnable.
PRELIMINARY DEPOSIT :—A Preliminary Deposit of 1% of total Tender Price is required to be lodged with Tender.
The Commission does not bind itself to accept the lowest Tender.
Tenders on prescribed form, properly endorsed, and addressed, must be delivered to the undersigned in Melbourne, not later than Twelve Noon on the 31st March, 1923.
R. LIDDELOW, Secretary. X 201

LIVERPOOL CORPORATION WATERWORKS.

VYRNWY SUPPLY.

NEW FILTER BEDS, OSWESTRY.

The WATER COMMITTEE of the Liverpool Corporation are prepared to receive

Tenders for the Construction

and Satisfactory COMPLETION of THREE FILTER BEDS and other ancillary Works, situated at Oswestry, in the County of Salop.
The Plans may be inspected and Copies of the Specification and Forms of Tender obtained at the Water Engineer's Office, Alexandra Buildings, 55, Dale Street, Liverpool, upon payment of the sum of Five Guineas, which amount will be returned upon receipt of a *bona fide* Tender.
Tenders, endorsed "Tender for Filter Beds," are to be sent through the post, in a sealed envelope, to the Town Clerk's Office, Municipal Buildings, Liverpool, addressed to the Chairman of the Water Committee, so as to be delivered not later than 12 o'clock Noon on Tuesday, 23rd January, 1923.
The Water Committee do not bind themselves to accept the lowest or any other Tender.
WALTER MOON, Town Clerk.
Municipal Buildings, Liverpool.
3rd January, 1923. X 241

THE GREAT INDIAN PENINSULA RAILWAY COMPANY.

The Directors are prepared to receive

Tenders for the Supply of the

following STORES, namely :—

		Fee for Specification.
No. 1.	Anvils	5/-
No. 2.	Firebricks and Fireclay ...	10/-
No. 3.	Copper Plates, Rods and Ingots	£1
No. 4.	Brass Sheets, Copper Tubes, &c.	10/-
No. 5.	Bolts, Nuts, Rivets, &c. ...	10/-
No. 6.	Axle-boxes for Carriages and Wagons	£1
No. 7.	Metals (Lead Sheets, Tinned Sheets and Aluminium)	5/-

Specifications and Forms of Tender may be obtained at this office on payment of the fee for the Specification, which payment will not be returned.
The fee should accompany any application by post. Cheques and Postal Orders should be crossed and made payable to the Great Indian Peninsula Railway Company.
Tenders must be delivered in separate envelopes, sealed and addressed to the undersigned, marked "Tender for Anvils," or as the case may be, not later than Eleven o'clock a.m., on Tuesday, the 16th January, 1923.
The Directors do not bind themselves to accept the lowest or any Tender.
E. H. WALPOLE, Secretary.
Company's Offices, 48, Copthall Avenue, E.C. 2.
London, 3rd January, 1923. X 258

BOMBAY, BARODA & CENTRAL INDIA RAILWAY COMPANY.

The Directors are prepared to receive up to Noon on Friday, 19th January, 1923,

Tenders for the Supply of :—

1. STEEL MATERIALS.
2. PUNCHING & SHEARING MACHINES.

Tenders must be made on forms, copies of which, with specification, can be obtained at these offices on payment of 10/- each (which will not be returned.)
The Directors do not bind themselves to accept the lowest or any Tender.
S. G. S. YOUNG, Secretary.
Offices : 91, Petty France, Westminster, S.W.1.
3rd January, 1923. X 264

APPOINTMENTS OPEN.

Experimental and Research

Work.—VACANCY in Glasgow for MAN with electrical instrument workshop training, testroom or laboratory experience, and general technical education. Applicants to state full particulars.—Address X 269, Offices of ENGINEERING.

Engineering Representative

(30–35) REQUIRED by leading London Firm. Shops and D.O. training essential. Experience in Heating and Ventilating and Fan Work desirable. State full details of experience and salary required.—Address, X 233, Offices of ENGINEERING.

Candidates for the Appoint-

ment of Assistant to the Manager, Calcutta, Box No. W 582, are thanked for their applications and are informed that the position has now been filled. X 219

Works Manager Required

for Non-Ferrous Sheet Metal Works in the East, under British control. Must be competent Engineer, Toolmaker-Draughtsman, familiar with modern coating methods and capable of handling native labour. Good prospects for right man. State age, qualifications, and remuneration expected.—Address, X 260, Offices of ENGINEERING.

Capable Engineers Required

by Manufacturers of Diesel, Semi-Diesel, Paraffin and Petrol Engines, stationary, portable and marine; also pumps and electric motors, to cover certain districts of Lancashire, Cheshire and North Wales.—Those with live connections and able to introduce business on a commission basis are invited to reply, with fullest particulars, whole or part time, etc., to BOX F941, LEE & NIGHTINGALE, Advert. Offices, Liverpool. X 229

A Resident Engineer is

REQUIRED by H.M. OFFICE OF WORKS to take charge of the erection of buildings, including reinforced concrete work, at Bangkok, Siam, extending over a period of possibly two years.
Applicant must be capable of taking executive control of the work during erection and must also be efficient in the calculations, design and details of reinforced concrete work and building construction.
Preference will be given to ex-service men.
Applications should be accompanied by copies of recent testimonials and should state age, salary required, whether married or single, and full particulars of qualifications and experience.
All communications should be addressed to The SECRETARY, H.M. Office of Works, Storey's Gate, Westminster, S.W. 1. X 212

INDIAN SERVICE OF ENGINEERS.

THE SECRETARY OF STATE FOR INDIA IN COUNCIL will in 1923

Appoint 11 Assistant

EXECUTIVE ENGINEERS for this Service if so many suitable candidates present themselves.
Every candidate must be a British Subject, or a ruler or subject of any State in India in respect of whom the Governor-General of India in Council has made a declaration that he is to be considered eligible.
European candidates who were of military age prior to November, 1918, must have served in His Majesty's Forces during the War, or have been prevented on adequate grounds from so serving. European candidates must have been born on or after 2nd August, 1898, and on or before 1st August, 1901.
Indian candidates must have attained the age of 21 and not attained the age of 24 years on 1st July, 1923, except that in the case of an Indian who has rendered service of the nature defined in the preceding paragraph, the same maximum age limit as for Europeans will apply.
Every candidate must either (1) have obtained one of certain recognised University degrees or other distinctions in Engineering, or (2) have passed Sections A and B of the Associate Membership Examination of the Institution of Civil Engineers, or been exempted by the Institution from such examination, or (3) produce the required evidence that he is otherwise eligible under the Regulations.
Applications from candidates must reach the India Office not later than 1st April. Printed forms, together with information regarding the conditions of appointment, may now be obtained from the SECRETARY, Public Works Department, India Office, Whitehall, London, S.W. 1.
India Office, London.
11th December, 1922. X 207

Draughtsmen Required. —

Only those possessing first-class aircraft experience need apply.—Write, giving full particulars of experience, age, and salary required, to THE FAIREY AVIATION COMPANY, LTD., Hayes, Middlesex. X 206

Draughtsman Wanted by

Engineering Firm in the Midlands experienced in Large Riveted and Welded Pipes for general purposes, also capable of designing and estimating Pipe Lines, etc., for Hydro-Electric Schemes. State experience, age and salary required.—Address, X 261, Offices of ENGINEERING.

Draughtsman, Accustomed to

Traction Control Gear, WANTED.—Address, stating age, experience, and salary required, X 154, Offices of ENGINEERING.

Wanted, by Leading Fir

SENIOR DRAUGHTSMEN with class experience for Layout and Detail work Switchgear, none but first-class men need apply Address, stating age, experience and salary requi X 94, Offices of ENGINEERING.

Electric Lifts. — First-cla

DRAUGHTSMAN for preparation of sche WANTED by Firm in Manchester district; JUNIOR. Permanency to good man.—Addr X 214, Offices of ENGINEERING.

Wanted Several Seni

DRAUGHTSMEN for London Office leading firm of Electric Crane manufacturers. S age, experience and salary required.—Address, X Offices of ENGINEERING.

Draughtsman Require

having recent experience in design Vertical two and three stage Compressors.—He stating age, career, and salary required, RAVELL & CO., LTD., Ranelagh Works, Ipsw X

Two Experienced Structur

DRAUGHTSMEN REQUIRED immedia for South Wales Works. Only first-class men n apply. State age, previous experience and sal required.—Address X 244, Offices of ENGINEERIN

Wanted, Draughtsman, we

up in Commercial Motor Design, Ste and Petrol. State age, experience and salary. Address, DRAUGHTSMAN, WM. PORTEOUS & C Advertising Agents, Glasgow. X

Wanted, Draughtsman, wit

good experience in Caterpillar Tracto State age, experience, and salary.—Addre CATERPILLAR, WM. PORTEOUS & Co., Advertisi Agents, Glasgow. X

Draughtsman Wanted, wit

good experience of machine tools, includi lathes and drilling machines of medium sizes. Address, stating experience, age, and salary r quired, X 246, Offices of ENGINEERING.

First - class Draughtsma

WANTED for Structural Steel Works in S.W London. Conservant with L.C.C. requirement Able to take work through; quick and reliable State age, experience, salary required, and whe free. Permanency to suitable man. — Addres X 259, Offices of ENGINEERING.

Required Immediately,

MECHANICAL DRAUGHTSMAN, wit sound knowledge of General Engineering Work and experience of tank and riveted work and esti mating for same.—Address, with full particulars X 267, Offices of ENGINEERING.

Draughtsman Required

by the GOVERNMENT OF NIGERIA for the MARINE DEPARTMENT for two tours of from 12 to 18 months' servic with possible extension. Salary £480 rising by £30 to £720 a year. Outfit allowance of £60 on first appointment. Free single quarters and passages. Liberal leave in England on full salary. Candidates aged 25 to 35, preferably unmarried, should be ship's draughtsmen with experience in designing river craft, barges, pontoons, etc. They should have had the usual training in shipyard work such as marking out and taking moulds for frames, and making calculations in connection with designs. Preferably should have had experience in the Engineering branch, should be capable of taking charge of the Headquarters drawing office and of giving instructions to African Draughtsmen in all branches of draughtsmanship.—Apply at once in writing stating age, giving a brief outline of qualifications and experience and stating whether married or single to THE CROWN AGENTS FOR THE COLONIES, 4, Millbank, London, S.W. 1, quoting M/11780. X 253

BOMBAY, BARODA AND CENTRAL INDIA RAILWAY.

PAINTER FOREMAN.

The Directors are prepared to receive

Applications (by letter only)

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S. G. S. YOUNG, Secretary.
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29th December, 1922. X 270

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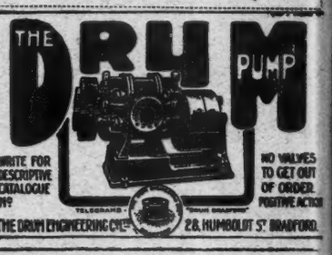
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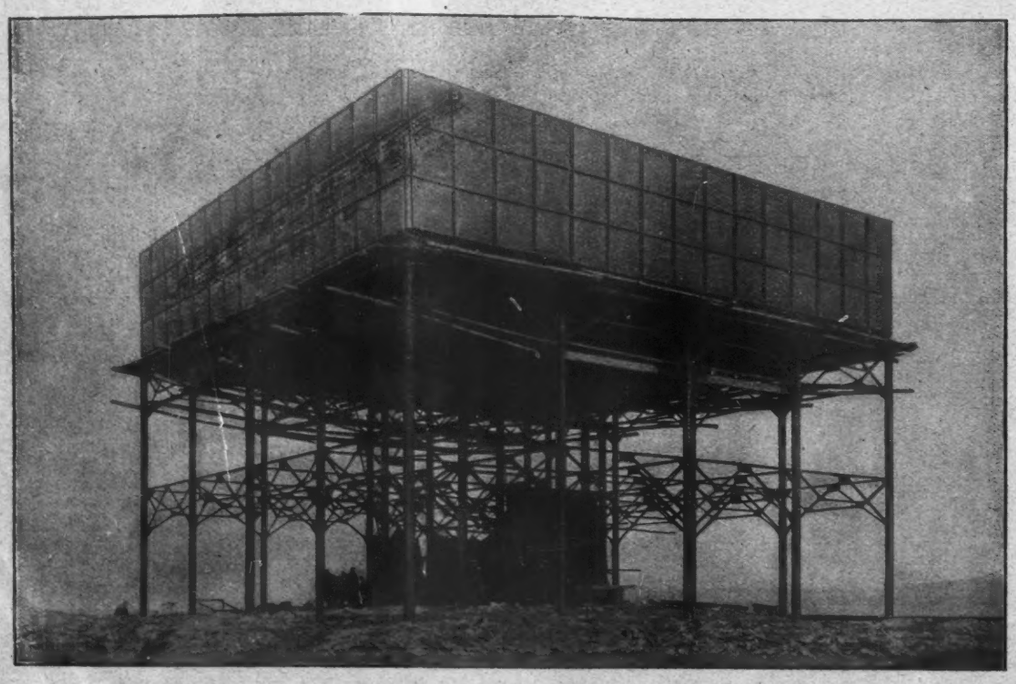

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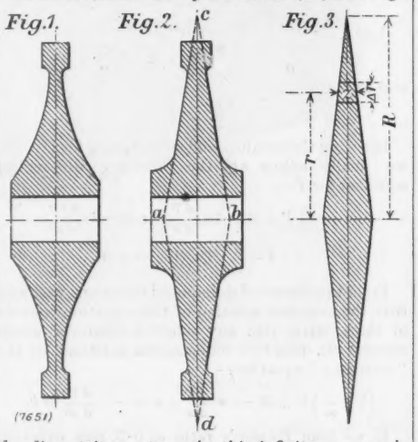
where r denotes the radius in question and C and a are numerical constants.

This problem appears to have been worked out in the first instance by Dr. de Laval, but his results were independently obtained by many later investigators, although they seem to have been first published by Professor Stodola. The formulæ thus obtained are of a type very inconvenient for practical use, but as was pointed out in ENGINEERING, the difficulty may be turned by adopting semi-graphic methods of calculation, and the system then described has been subsequently still further developed by Mr. W. Knight, who computed and plotted many additional curves which were published in our issue of August 3, 1917. With the same assumptions as to the boundary conditions these diagrams necessarily yield the same results as the formulæ from which they are derived. This point seems to have been frequently overlooked, and naturally if one hypothesis is adopted in determining stresses from the diagrams and another in computing them from the original formulæ, discrepancies are bound to appear.

When the thickness of the disc varies according to the law $z = \frac{C}{r^a}$ the resultant profile is of the type represented in Fig. 1. The bounding curves are somewhat troublesome to machine, and accordingly there has been a tendency towards the adoption of straight-sided profiles such as is represented in Fig. 2. If the straight sides are produced, as indicated by the dotted lines, to cut the axes of rotation at a and b, and in the opposite directions to intersect at c and d, the disc included between these lines consists of two cones placed base to base, and if the stresses in this "generalised" form can be found, we can also deduce those in any practical form derived from it.

So far as the writer is aware no general solution for the stresses which arise in these conical discs has hitherto been published, although some nine or ten years ago an approximate arithmetical solution, which involved the solving of a number of simultaneous equations, appeared in the *Revue Mecanique*.

From the mathematical standpoint the general problem reduces itself to the determination of the stresses produced in the solid double cone d, a, c, b (represented in Fig. 2) by two different sets of forces, viz., (1) by the centrifugal forces acting alone, and (2) by the application of a load of say 1 lb. per inch run applied along the knife-edge forming the periphery. For the complete solution we also require to know the stresses which would be produced in the disc by an infinitely great pressure applied to the interior of an infinitely small hole drilled through



the disc at its centre. As this infinite pressure is applied over an infinitely small area, the stresses are finite everywhere save at the surface of the infinitely small hole.

If we can determine the stresses due to these three independent systems of loading we can deduce from them the stresses developed in any concentric annulus cut from this rotating disc, loaded at its periphery with blading and joined on to a hub at its inner periphery.

Let the outer diameter of the disc be 2 R (see Fig. 3), and let r be any other radius. Consider a thin ring at this radius of radial thickness Δr. Then if this ring were completely isolated and rotating, the tangential stress developed in it by the centrifugal forces is accurately given in lb. per square inch by the expression

$$t = 2\left(\frac{d}{10}\right)^2\left(\frac{\text{R.P.M.}}{100}\right)^2.$$

In this formula it is assumed that the material is steel* whilst d denotes the mean diameter of the thin ring expressed in inches.

The total tangential pull is equal to the stress t multiplied by the cross-section of the ring, that is to say, it is equal to $t\,z\,\Delta r$.

Actually, the ring is not free, but forms part of the disc and is thus subjected to radial tensions on its inner and outer surfaces. Let us denote those on the inner surface by p where p is expressed in pounds per square inch. Then by the ordinary formula for the strength of boiler shells this load will produce a total tangential force on the ring equal to $p\,z\,r$. The stress p being a tension, the resultant tangential force in the ring will be a thrust. Coming next to the external periphery of the ring we note that $p\,z\,r$ is a function of r, hence, by Taylor's theorem, the total tangential force due to the tension applied to this outer periphery of the thin ring will be

$$p\,z\,r + \frac{d}{dr}.(p\,z\,r)\,\Delta r + \text{terms}$$

involving higher power of Δr which may be neglected when Δr is small. This tangential force is obviously a tension. The total resultant tangential force on the ring is the algebraic sum of these three terms. If the resultant stress be denoted by q this resultant tangential force will be $q\,z\,\Delta r$, and we thus get the relation

$$qz\,\Delta r = tz\,\Delta r - pzr + pzr + \frac{\delta}{\delta r}(pzr)\,\Delta r$$

Whence

$$qz = \frac{d}{dr}(pzr) + tz \quad . \quad . \quad (1)$$

This equation gives one relation between the radial stress p and the tangential stress q. It is convenient to replace t by $\frac{T}{R^2}r^2$, where T is equal to

$$2\left(\frac{D}{10}\right)^2\left(\frac{\text{R.P.M.}}{100}\right)^2,$$

D being the external diameter of the disc, *i.e.*, D = 2 R. Hence we get from (1)

$$qz = \frac{d}{dr}(pzr) + \frac{T}{R^2}r^2z \quad . \quad . \quad . \quad (2)$$

In the foregoing it has been assumed that the stresses p and q may without any very serious error be taken as uniformly distributed over the sections on which they act. This assumption is the usual one made by Professor Stodola and others, and even within the elastic limit the condition is approximately satisfied if the faces of the double cone do not make a large angle with each other. So far as the ultimate strength of the disc is concerned, the

* For other materials the coefficient 2 should be increased or decreased in the ratio of the specific gravity of the material used to the specific gravity of steel.

hypothesis is very nearly true, even if the angle between the faces be fairly large.

There are various ways of eliminating q from equation (2). Perhaps that least open to criticism is based on Castigliano's theorem. Every elastic structure when stressed acts as a spring, and in virtue of being in a state of stress has accordingly stored up in it a certain potential energy. By Castigliano's principle, the stresses always adjust themselves so that this "potential energy of strain" is a minimum, consistent with the equilibrium of the forces acting on the structure. One advantage of this principle is that it is often possible to see from general considerations that certain of the stresses will contribute little to this store of potential energy, whilst in the other cases what they do contribute will vary but little with any reasonably conceivable distribution of the remaining stresses. In both cases, accordingly we need take into consideration only these remaining stresses. In the present case these considerations do not arise as it has already been assumed that the only stresses with which we need concern ourselves are p and q. Let e be the radial strain at any point of the disc where the radial tension is p. Then the strain energy stored up in one cubic inch of the metal, due to the stress p, is $\frac{p\,e}{2}$. Similarly, if f be the tangential strain, the work stored up in one cubic inch, due to the stress q, is $\frac{q\,f}{2}$. Since the total volume of our thin ring is $2\,\pi\,r\,z\,d\,r$ cubic inches the total work stored in it is

$$2\,\pi\,r\,z\left(\frac{p\,e}{2}+\frac{q\,f}{2}\right)d\,r.$$

If $\frac{1}{m}$ denotes Poisson's ratio, we have

$$e=\frac{p}{E}-\frac{1}{m\,E}\,q$$

whilst

$$f=\frac{q}{E}-\frac{1}{m\,E}\,p.$$

Substituting these values for f and e we get for the work $d\,W$ stored in our elementary ring the expression

$$d\,W=\frac{\pi}{E}.r\,z\left(p^2-\frac{2\,p\,q}{m}+q^2\right)d\,r.$$

The work W stored up in the whole disc is found by integrating this between $r=0$ and $r=R$. Whence

$$W=\frac{\pi}{E}\cdot\int_0^R\left(p^2-\frac{2\,p\,q}{m}+q^2\right)r\,z\,d\,r \quad . \quad (3)$$

and by Castigliano's principle this must be a minimum.

It is convenient to change the variable from r to x where $x=\frac{r}{R}$, so that $d\,r=R\,d\,x$. Then, if Z be the thickness of the disc at the centre, the thickness at any other point is given by $z=Z\,(1-x)$. Making these substitutions in (2) gives

$$(1-x)\,q=\frac{d}{d\,x}p\,(1-x)\,x+T\,x^2\,(1-x) \quad . \quad (4)$$

whilst, ignoring certain constant coefficients, the integral in (3) reduces to

$$\int_0^1\left(p^2-\frac{2\,p\,q}{m}+q^2\right)x\,(1-x)\,d\,x \quad . \quad (5)$$

The mathematical work can be simplified by two further substitutions, viz., $P=(1-x)\,p$ and $Q=(1-x)\,q$. We thus get from (4)

$$Q=P+x\frac{d\,P}{d\,x}+T\,x^2\,(1-x) \quad . \quad . \quad (6)$$

whilst (5) becomes

$$\int_0^1\left(P^2-\frac{2\,P\,Q}{m}+Q^2\right)\frac{x}{1-x}\,d\,x \quad . \quad . \quad (7)$$

Let us denote the expression in the brackets by V. Then the calculus of variations shows us, that for this integral to be a minimum as required by Castigliano's theorem, we must have

$$\frac{x}{1-x}\cdot\frac{d\,V}{d\,P}-\frac{d}{d\,x}\cdot\frac{x}{1-x}\cdot\frac{d\,V}{d\,P'}=0 \quad . \quad (8)$$

Where P′ is "shorthand" for $\frac{d\,P}{d\,x}$,

obviously

$$\frac{d\,V}{d\,P}=2\,P-\frac{2\,Q}{m}-\frac{2\,P}{m}\frac{d\,Q}{d\,P}+2\,Q\frac{d\,Q}{d\,P}.$$

From equation (6) we see that $\frac{d\,Q}{d\,P}=1$.

USE OF REINFORCED CONCRETE IN PIT-HEAD GEARS.

(For Description, see opposite Page.)

FIG. 1. HEADGEAR AND RECEIVING PLATFORMS AT THE LIMBOURG-MEUSE COLLIERIES.

Again,

$$\frac{d\,V}{d\,P'}=-\frac{2\,P}{m}\frac{d\,Q}{d\,P'}+2\,Q\frac{d\,Q}{d\,P'},$$

and from (6)

$$\frac{d\,Q}{d\,P'}=x.$$

Inserting these values and substituting for Q in (8) we finally arrive at the following differential equation for P—

$$\left(1-\frac{1}{m}\right)P+(3-2\,x)\frac{d\,P}{d\,x}+x\,(x-1)\frac{d^2P}{d\,x^2}+\left(3-\frac{1}{m}\right)T\,x\,(1-x)^2=0 \quad . \quad . \quad (9)$$

From the theory of differential equations we know that the complete solution of this equation consists of three parts, viz., any solution whatever which satisfies (9), plus two independent solutions of the "auxiliary" equation—

$$\left(1-\frac{1}{m}\right)P+(3-2\,x)\frac{d\,P}{d\,x}+x\,(x-1)\frac{d^2P}{d\,x^2}=0.$$

If we take Poisson's ratio as 0·3, this equation becomes—

$$0\cdot7\,P+(3-2\,x)\frac{d\,P}{d\,x}+x\,(x-1)\frac{d^2P}{d\,x^2}=0 \quad (10)$$

Solutions of this can be found in the form of infinite series. One such solution, valid for all values of x between 0 and 1, is—

$$P_1=A\left(1-\frac{0\cdot7}{3}x-\frac{0\cdot7}{3}\cdot\frac{1\cdot3}{8}x^2-\frac{0\cdot7}{3}\cdot\frac{1\cdot3}{8}\cdot\frac{5\cdot3}{15}x^3-\&c.\right)$$

Here A is an arbitrary constant. We defer for the present the consideration of the physical significance of this solution, and thus merely note in passing that the radial stresses due to P_1 are equal to $\frac{P_1}{1-x}$.

The corresponding tangential stresses are equal to $\frac{Q_1}{1-x}$ where

$$Q_1=P_1+x\,\frac{d\,P_1}{d\,x}.$$

A second independent solution of (10) is—

$$P_2=B\,(1-x)^2\left(1+\frac{5\cdot3}{3}(1-x)+\frac{5\cdot3}{3}\cdot\frac{11\cdot3}{8}(1-x)^2+\frac{5\cdot3}{3}\cdot\frac{11\cdot3}{8}\cdot\frac{19\cdot3}{15}(1-x)^3+\&c.\right)$$

Here B is another arbitrary constant. This series is convergent for all values of x between 0 and 1, but becomes infinite when $x=0$. The radial stress $\frac{P_2}{1-x}$ is that due to an infinite pressure applied to the interior of an infinitely small hole drilled through the centre of the disc. The corresponding tangential stress $\frac{Q_2}{1-x}$ is derived from the expression—

$$Q_2=P_2+x\,\frac{d\,P_2}{d\,x}$$

The solution of the original equation (9) is easily derivable from P_1 or can be obtained directly by the usual symbolic methods, on changing the variable from x to θ where θ is defined by the relation $x=e^\theta$. Denoting the solution thus found by P_3 we have—

$$Q_3=P_3+x\,\frac{d\,P_3}{d\,x}+T\,.\,x^2\,(1-x).$$

The stresses due to a combination of those corresponding to P_1 and P_3 are

$$p=\frac{C\,P_1+P_3}{1-x}$$

and

$$q=\frac{C\,Q_1+Q_3}{1-x}.$$

Here C denotes a constant, chosen so as to make $C\,P_1+P_3=0$ when $x=1$. If we put $C\,P_1+P_3=\phi$ and $C\,Q_1+Q_2=\psi$, values of ϕ and ψ for different values of x are tabulated in Table I, together with corresponding values of P_1, P_2, and Q_1, Q_2. Both the series for P_1 and P_2 converge very slowly for certain values of x. In the first case the convergence is slow when x is nearly unity, and the second case

THE USE OF REINFORCED CONCRETE IN PIT-HEAD GEARS.

FIG. 2. GENERAL VIEW OF THE PIT-HEAD WORKS AT THE LIMBOURG-MEUSE COLLIERIES.

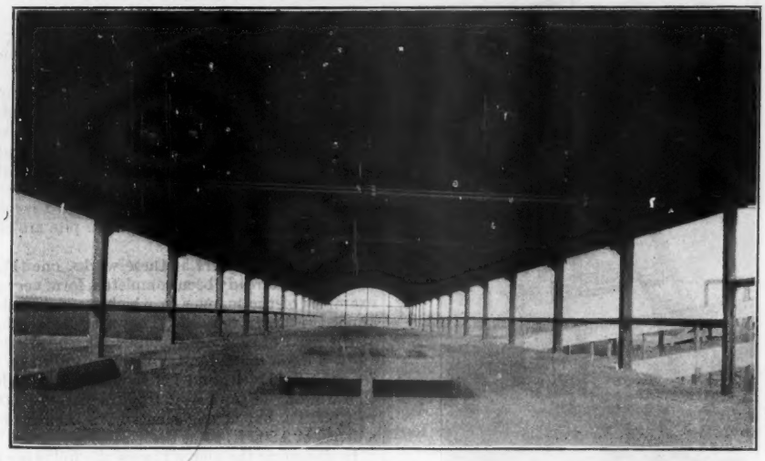


FIG. 3. THE ELEVATED TIPPING SHED AT THE LIMBOURG-MEUSE COLLIERIES.

the convergence is extremely slow when x is nearly zero. Fortunately, however, after some 50 terms

TABLE I.

x	P_1	Q_1	$-P_2$	Q_2	$\phi = T\,x$	$\psi = T\,x$
0·0	1·00000	1·0000	—	—	0·13547	0·13547
0·05	—	—	259·74	2·7418	—	—
0·10	0·97627	0·95214	59·957	69·549	0·12913	0·12883
0·15	—	—	24·380	31·065	—	—
0·20	0·95170	0·90163	12·431	17·525	0·11736	0·12136
0·25	—	—	7·1497	11·159	—	—
0·30	0·92616	0·84799	4·4597	7·6257	0·10160	0·11280
0·35	—	—	2·8517	5·5453	—	—
0·40	0·89953	0·79060	1·8949	4·1494	0·083300	0·10350
0·45	—	—	1·2804	3·1844	—	—
0·50	0·87163	0·72853	0·87163	2·4718	0·063876	0·091357
0·60	0·84220	0·66047	0·39950	1·5264	0·044768	0·077927
0·70	0·81091	0·58400	0·17011	0·93046	0·026904	0·062332
0·80	0·77723	0·49618	0·059426	0·52287	0·013232	0·044278
0·90	0·74021	0·38668	0·012053	0·2263	0·0036193	0·022706
1·00	0·69702	0·20911	—	—	—	—

have been directly computed an asymptotic recurrent series can be substituted for the remainder, and the sum of such a recurrent series can be expressed in a finite form. Advantage has been taken of this in computing some of the values printed in Table I. With the aid of this table the stresses in conical discs can be computed about as easily as they can in the case of a disc of uniform thickness.

(To be continued.)

THE USE OF REINFORCED CONCRETE FOR PIT-HEAD GEARS.

By W. L. SCOTT, A.M.Inst.C.E.

DURING the war and for some time after its conclusion, the interchange of civil engineering ideas and experience between this country and the various other European countries involved, unavoidably lapsed, and the large amount of building work going on in connection with the reconstruction of the devastated areas includes many innovations not yet brought to the notice of engineers in this country. An instance of this is to be found in the great strides that have been made in the North of France and in Belgium in the development of reinforced concrete for industrial and other works hitherto carried out almost exclusively in steel, timber or brick work.

In certain areas, notably in the Lens and Bethune districts, the industrial buildings were entirely demolished, and before proceeding with their reconstruction it has been possible to replan them on the most modern lines, utilising to advantage the experience gained and progress made since their earlier erection. Very considerable ingenuity has been shown by French engineers in the lay-out and arrangement of these new works, and a visitor to the devastated regions of northern France cannot help being impressed by the extent to which reinforced concrete is being applied in this direction. The change in the use of materials mentioned above is perhaps most marked in the case of the rebuilding of mining installations. Whereas, before the war, it was exceptional for reinforced concrete to be employed for such use as pit-head gears, the writer cannot recall having seen during a recent visit to these parts, a single case of a head gear being reconstructed either in timber or in steel. There were, however, many instances of the use of reinforced concrete. Some of these are complete and have been in use for a considerable time. The designing engineers for all the works dealt with in this article were Messrs. Pelnard, Consid re, Caquot et Cie., of Paris. In the preparation of the designs, consideration only has been given to the actual work and stresses imposed upon the head gears, no attempt being made to follow the arrangement adopted in the designs of the older timber and steel structures.

In pioneer work where concrete has been employed as a substitute for steel or timber for other engineering structures, the arrangement used in the previous designs has been too frequently adopted, and the resultant loss of economy can be readily seen by a brief examination of certain of the earlier types of wharves and jetties erected in reinforced concrete, both in this country and abroad.

The accompanying illustrations, Figs. 1 to 8, on pages 1 to 5, show more clearly than any

THE USE OF REINFORCED CONCRETE IN PIT-HEAD GEARS.

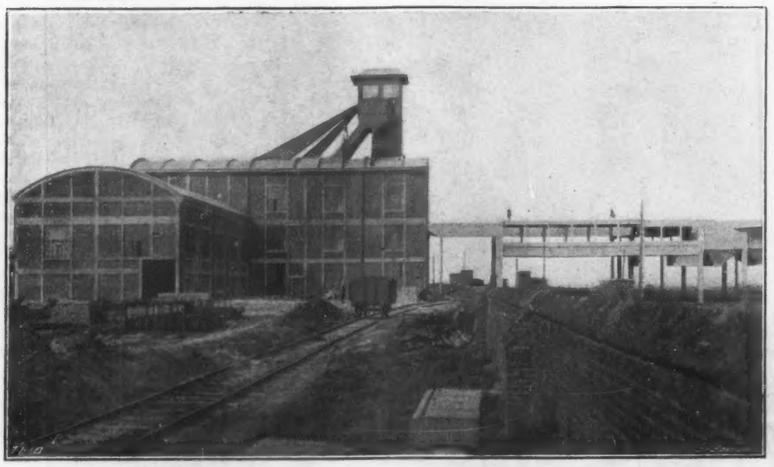


FIG. 4. BUILDINGS AT NO. 4 PIT; BETHUNE COMPANY'S WORKS.

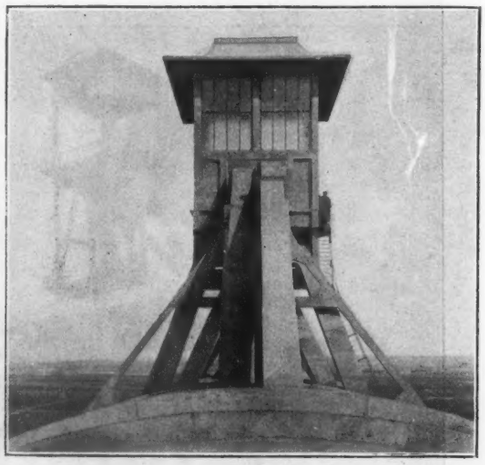


FIG. 5. ENCLOSED CABIN AND CABLE SHEATHS AT THE BETHUNE COMPANY'S WORKS.

written description the types of reinforced concrete head gears already constructed. It is not possible to give a general description which would be applicable to these structures as a whole, since at the various pits differing conditions have necessitated the designs for the towers and adjacent buildings of each pit being treated separately upon their merits. There are, however, some points in the design of these head gears common to all or most of them, which may be of interest to the reader.

In every case the towers have been provided with ample accommodation at the head wheel levels, and a roof has been added which gives protection to the wheels, &c., against weather. Attention has also been paid to the appearance of the upper part of these towers, since, although in the immediate vicinity of the works architectural effect may be held to be of no serious moment, these head gears in some cases are considerably more than 100 ft. high and situated as they are in flat country, can be seen for many miles. The back inclined legs are designed to withstand the compressive force resultant from a pull on the winding rope equal to its breaking strength, this, of course, being a possible condition due to overwinding. The breaking strength of the ropes in the head gears dealt with here, vary between approximately 50 tons and 200 tons.

In some cases, for instance, at the No. 4 and No. 7 mines belonging to the Bethune Company, the inclined legs as well as the vertical legs pass through the adjacent receiving and check-weighing buildings. Where this occurs, a space has been left around them at their points of penetration through the roof and floors below. The reason for this is due to the fact that while working, the pit-head building may be subject to considerable vibration and also that under exceptional circumstances the head gear may have imposed upon it very serious stresses, and in view of this it has been considered desirable by the designers to permit the tower structure to stand alone so that its elasticity as a whole may not be impaired.

In cases where the rear inclined legs are at a large angle with the tower due to the winding-house being situated some distance from the pit mouth, it will be noticed that the profile is somewhat unusual, the underside being kept a straight line and the section increased in area towards its mid-length. Since these members are unsupported vertically and span between the tower at their upper end and their bases at the ground level, considerable bending moments are developed due to their own deadweight. As an offset to this the compressive force transmitted to the legs resultant from the pull on the winding ropes, is designed to pass through a point below the centroid of the

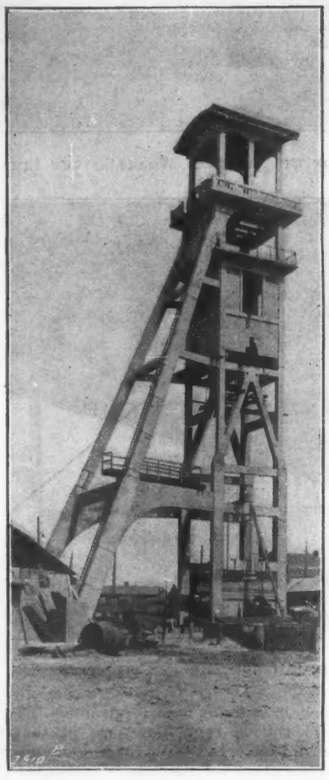


FIG. 6. HEAD GEAR OF NO. 1 PIT; LENS MINES COMPANY.

section, thereby producing an approximately uniform compressive stress due to the combined thrust and bending, and preventing any over-stress in the top flange. It will be noted that the principle stress throughout these head gears is compression, and consequently reinforced concrete is a material very economically suited for their construction.

In the case of the pit-head gears to the Limbourg Meuse Collieries, illustrations of which are given in Figs. 1 to 3, pages 2 and 3, special arrangements were required in connection with the foundations of the vertical legs of the tower owing to the preliminary bores entailed, in connection with the freezing process used in sinking the shafts. In erecting these works satisfactorily some difficulty presented itself, as it was necessary to carry on the construction without interrupting the sinking operations for the mine shafts, in connection with which there was a considerable amount of machiney and plant scattered over the site of the proposed structures. It is to the credit of the contractors, Messrs. M. Monnoyer and Sons, of Brussels, that this was successfully accomplished without an accident of any kind occurring, notwithstanding that during this period over 11,000 tons of material were removed from No. 1 pit.

The pit-mouth building occupies a rectangular space of about 70 ft. by 50 ft. It consists of two receiving platforms respectively 35 ft. and 44 ft. above ground level, and is covered by a parabolic vaulted concrete roof stiffened by ribs spaced about 20 ft. apart, tied by means of tie-beams suspended from the roof. The reason for the two receiving platforms is that the cages for these pits are of the "double-deck" type.

The pit-head towers at these works, one (Fig. 1) of which has already been completed, form very good examples of the manner in which concrete is being applied to these structures. They are 151 ft. high, and at the head of each are installed four head wheels, 19 ft. 8 in. in diameter, two being installed on axes respectively 114 ft. and 121 ft. above ground level. The winding is at present from depths of 2,300 ft. to 2,600 ft., but arrangements have been made for a depth of 3,200 ft. to be dealt with.

In designing the above towers the following data were used:—

Diameter of shaft	20 ft.
Number of cages	2
Dimension of cages	10 ft. 9 in. by 3 ft. by 23 ft.
Weight of one cage with eight tubs	19·5 tons.
Weight of winding rope ...	28 lb. per yard.
Stress on rope when winding ...	32 tons.
Distance from centre line of pit to foot of strut	80 ft.
Lateral distance between feet of struts	35 ft.
Distance between axis of pits and Koepe pulleys	155 ft.
Total weight of head gear ...	700 tons.

The inclined legs are arranged in these head gears without any lateral support in the vertical plane, and as described above are designed to resist the breaking strength of the winding rope, amounting in this case to 212 tons.

The three illustrations given of these works show several interesting features, and the arrangement of bracing to the tower of the head gear already completed is clearly indicated. It will

THE USE OF REINFORCED CONCRETE IN PIT-HEAD GEARS.

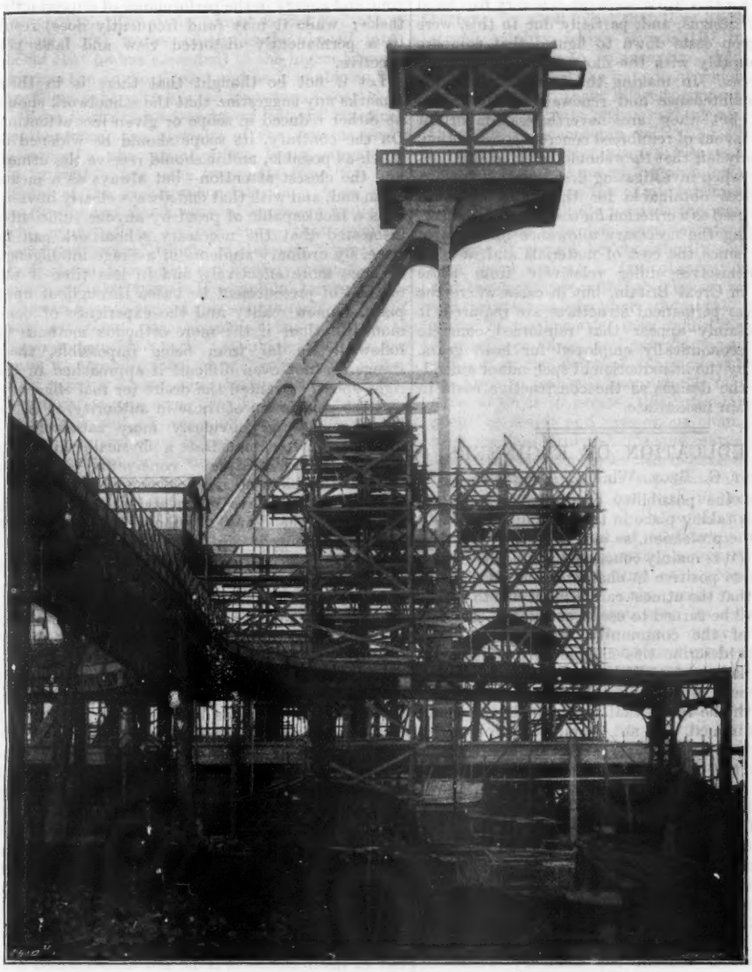


FIG. 7. PIT-HEAD GEAR; SOCIÉTÉ DES MINES DE DOURGES.

FIG. 8. PIT-HEAD GEAR AND RECEIVING BUILDING COMPLETED AT DOURGES.

also be seen from the photographs, especially the view in Fig. 2, to what an extent reinforced concrete has been applied in the work adjacent to the head gears, these latter structures forming only a very small part of the total reinforced concrete scheme. Fig. 3 is a view of the elevated tipping floor, which is covered by a somewhat novel form of concrete roof, similar in type to that over the pit mouth building briefly described above.

An interesting illustration is that of the head gear at No. 1 pit of the Lens Mines Company (Fig. 6). This is one of three which are identical in type and owned by the same company. The total height from the ground to the roof of the tower is 111 ft. 6 in. These particular head gears are of a special type, the reason being that they were first of all used in connection with excavating and pumping out the pits that had been completely demolished by the Germans. The pumps used were very cumbersome, and were suspended from a pulley attached to stout wooden beams about 52 ft. above the ground. The cable then ran down vertically to another pulley at the foot of the tower, and was eventually wound on to a winch some little distance away. As soon as the pits were pumped dry the pumps were removed and the guides for the cages were put in place, the cables from which the cages were suspended passing over the upper head wheels. The wooden beams which were temporarily used in connection with the pumping were removed in order to give a free passage to the cage in the event of over-winding. These wooden beams were then utilised for holding the safety stops.

When these works are completed the head gears will be surrounded by buildings, and the enclosed cabin shown in the illustration has been introduced in order to facilitate the sealing of the roof to the future building at the point where the tower penetrates it. The following data were employed in the design of these head gears:—

Diameter of pulleys	11 ft. 6 in.
Weight of one pulley	6 tons.
Weight of two pulley blocks ...	3 tons.
Distance between centres of pulleys	5 ft. 10 in.
Breaking weight of cable ...	71 tons.
Normal load raised	10 tons.
Height from ground to axis of pulleys	95 ft.
Load on pump cable	41·4 tons.

It may be of interest to give some of the general dimensions and levels usually adopted for the design of headgears in France and Belgium. The main receiving floor is situated from 33 ft. to 40 ft. above the ground level. Should the cage be of the "double-deck" type an extra receiving floor is constructed from 40 ft. to 47 ft. above the ground. This condition, it will be noted, obtains in the Limbourg Meuse installation, previously mentioned. After arriving at the receiving floor the tubs run straight down to the screening sheds and return empty to their starting point. The tubs discharge their coal into the screens, and the coal falls gradually from screen to screen until it reaches the lowest line of hoppers under which the railway trucks travel. This fixes the minimum height of the receiving floors at 33 ft. to 40 ft. above ground.

If the receiving floor is, say, 36 ft. from the ground, and the cage has a height of 20 ft., the coupling device between the cable and the cage will be at the 60-ft. or 62-ft. level. The head wheels will, therefore, be at a level of about 78 ft. to 80 ft. above ground. Beneath these are placed the safety devices, the function of which is to stop the cage and prevent it striking the head gear in case of over-winding due to an error of judgment of the operator, or a failure of the automatic stopping device in the engine-room.

To dismantle and remove the cages the following method is employed: The underside of the cage is raised about 5 ft. above the ground. The pit mouth is then closed by panels fitted with rails which coincide with the track laid on the ground. A special truck is now run in and the cage lowered on to it. The cable is then unhooked and the cage run out clear of the framework of the tower.

With regard to the safety device, it is found in practice that if the cage passes the receiving floor level at full speed it will hit the stopping device with such force as to cause very serious damage. On the assumption that the cage is liable to run up to the head wheels the tower has to be provided with some sort of cabin to retain the damaged cage after striking the buffer beams. In the upper part of this chamber the buffer beams are situated, and at its floor level are placed the safety stops which are pushed aside as the cage ascends, and fall into position again automatically and prevent the cage from dropping after the cable has broken. In the case of the pit-head gear at Lens the beams holding the buffers are in the roof of the cabin at about the 72-ft. level, and the safety stop beams are at the 53-ft. level.

For many years in France the question of

automatic safety devices has been the subject of much discussion. Some engineers are of the opinion that by introducing automatic safety devices the men in charge of the winding gear are liable to rely too much on the automatic gear instead of watching the operation themselves. Actually there are no automatic devices which are infallible, a remark which is applicable not only to mine workings, but also to railways, and, as is very well known, more reliance is placed on the vigilance of the man in charge than on any automatic safeguards. On the other hand, safety devices have become the rule in the mining world, but it appears that they are practically always duplicated.

It is considered by many engineers that the simplest and surest method to prevent the cage being overwound and damaging the head tower is to have the guides constructed so that they incline inwards slightly, and the cage as it ascends beyond its correct level gradually becomes wedged in them. The pressure thus exerted by this method of braking whilst sufficient to buckle the frame of the cage, checks it very effectively, and absorbs the shock.

Whilst the question of the safe manipulation of the cages does not affect the relative merits of reinforced concrete head gears, it is important from the structural point of view owing to the desirability of eliminating as far as possible any chance of damage to the head towers.

In the case of mine No. 4, belonging to the Bethune Company, the head of the tower is completely enclosed, as shown in Figs. 4 and 5, and the winding ropes where they pass from the pulleys to the building below are encased by concrete sheaths of inverted channel section to protect them from the weather. This casing—which is only about 2 in. thick—is clearly shown in Fig. 5. The provision of these sheaths in reinforced concrete illustrates the precautions which have been taken to reduce to an absolute minimum the amount of exposed steelwork so that the cost of external maintenance shall be as far as possible eliminated.

Regarding the roof and framing for the head wheels in the above head gears, the appearance of these suggests that their principle object is to provide the wheels with protection from weather. This is not strictly correct, since a more important function of this top framing is to provide the necessary supports for the tackle by which the head wheels are removed. Most of these head wheels are removed in two halves, since their diameter usually exceeds the internal dimension of the tower. In some cases a simple pulley is employed, and the head wheels are suspended on a cable passing to a winch situated on the ground some distance from the tower. With this arrangement the top framing may be subjected to very important transversal stresses, which necessitate the introduction of either strong pillars and cross diagonals, as in the case of the Dourges head gear (Figs. 7 and 8), or alternatively solid walling, which was adopted for the Limbourg Meuse Works.

At the conclusion of the war there was great difficulty in obtaining rolled steel sections of the shape and dimensions required for a head gear, and it was principally owing to this that reinforced concrete was introduced for this work on so large a scale. The necessary steel rods forming the reinforcement were available in France, and it was possible in three or four months to construct a complete head gear, this period being at that time insufficient for the delivery even of the necessary structural steel work.

In the earlier pit-head gears the designers only employed concrete for the struts and supports to the head wheels, steel being utilised for the construction of the tower itself. This arrangement was adopted for the pit head gear at Dourges, illustrations of which are given in Figs. 7 and 8, page 5. The first of these shows the head wheel structure standing alone, and the second the structure completed with the steel cage towers, and the surrounding buildings. It was found after the gears had been working for some time, that there was no appreciable vibration of the reinforced concrete work, and a further step was therefore taken, and in subsequent installations the tower was also constructed in the same material.

Distinct from the question of the structural efficiency of these head gears and adjacent works is the very important question of first cost. In view of the present industrial situation, engineers rightly give the latter question equal consideration with the former. Messrs. Considère, when appointed engineers for this work, were given a very free hand with their designs, and, partially due to this, were able to keep costs down to figures that compare very favourably with the more common steel and timber types. In making these comparisons, the cost of maintenance and renewals has been disregarded, but they are nevertheless important factors in favour of reinforced concrete construction, and it is only fair that they should be given due consideration when investigating first costs.

The prices obtainable for the foregoing work cannot be used as a criterion for costs in this country, even making the necessary allowance for rates of exchange, since the cost of materials and rates of labour themselves differ relatively from those obtaining in Great Britain, but in cases where the more or less permanent structures are required, it would certainly appear that reinforced concrete could be economically employed for head gears, especially by the introduction of such minor amendments to the designs as the constructive costs in Great Britain necessitate.

THE EDUCATION OF ENGINEERS.

By ERNEST G. BECK, Wh.Ex., Assoc.M.Inst.C.E.

BEYOND the possibility of doubt or question, a change is taking place in the very substance and fabric of the profession, as well as in the industries with which it is mainly concerned; and this change is at once so positive in character and so right in tendency that the utmost care is necessary to ensure that it shall be turned to useful account in the best interests of the community as a whole. Any attempt to describe this change in precise terms would be likely to serve little or no practical purpose; while it would probably lead to argument on mere words, with the result that the main issues would become dimmed, if not completely obscured. Speaking broadly, however, there are clear indications that the change is being brought about by a demand for the adoption of a more human attitude towards all aspects of the work—a plain and natural outlook, free from affectation, mysticism and all that savours of the exclusive cult, upon even the more highly scientific portions of design, administration and research.

There is no reason whatever to fear that the simplification of engineering education by this means would in any way weaken or lower the status of the profession—indeed, the tendency would be distinctly and strongly in the opposite direction, since emphasis would be laid upon the importance of skill in the practical application of knowledge rather than upon the mere absorption of multitudinous facts and principles. True distinction is not to be acquired through the rendering of stock answers to a few stock questions concerning the acrobatic exploits of "*i*," any more than through the mispronunciation of simple English words. Scientific knowledge is not the only ingredient necessary for the making of an efficient engineer; and although knowledge of ascertained fact is required (and in the fullest possible measure) in order that it may be employed as a basis for projected designs, the knowledge likely to be most valuable as giving clear vision in these respects is that full comprehension of plain physical reality which enables a man to form a reliable prediction as to the probable consequences of a proposed action, and to trace backwards accurately from an observed result to the causes of which it is the effect.

Practically all the school work which is so commonly—and so wrongly—regarded as the "education" of an engineer is in fact no more than the preliminary equipment necessary as a groundwork or basis upon which his education may be built. And just as over-elaboration or disproportionate refinement in the foundation for a structure—anything, in fact, which tends to invest the foundation with a false importance of its own, apart from its only true function of supporting the particular structure for which it is designed—cannot fail to affect adversely the structure as a whole, so the over-elaboration or disproportionate refinement of mere schoolwork—anything, in fact, which tends to present it otherwise than as a preparation for practical work—inevitably hinders the real education of an engineer. At the best it will absorb time and energy in the performance of unproductive tasks; while it may (and frequently does) result in a permanently distorted view and false perspective.

Let it not be thought that there is in these remarks any suggestion that the schoolwork should be either reduced in scope or given less attention. On the contrary, its scope should be widened as much as possible, and it should receive the utmost and the closest attention—but always as a means to an end, and with that end always clearly in view. It is a fact capable of proof by anyone sufficiently interested that the necessary schoolwork can be done, by ordinary students of average intelligence, at once more effectively and in less time if the method of presentment be based throughout upon plain, human reality and the experience of common life than if the more orthodox methods be followed. So far from being impossible, these things are not even difficult if approached in the right spirit. Granted the desire for real efficiency, and the permission of those in authority, it is less troublesome—and obviously more satisfactory—for a teacher to demonstrate a physical reality than to expound an abstract "conception" which is supposed to have no physical counterpart.

The error we have made and are still making lies not in the doing of schoolwork, but in our manner of doing it—in the false elevation into an end in itself of that which can never, in truth, be more than a means to an end. Schoolwork, properly regarded, should provide the student with his stock methods for doing things—*i.e.*, what may be called his rudimentary technique. It is not by any means the technique which he actually employs in his practical work, for that he builds up and develops day by day throughout his life, improving old methods and devising new to suit his own individual needs as new difficulties are encountered. It is merely the broad survey of salient features in their proper relation, about which the whole scheme may be explored without confusion or error—tending to prevent the production of mere monstrosities, and also the "discovery" of things which have been already proved worthless. Thus, it is enormously important as a basis for the later development, for if well done and truly regarded it will provide a sure foundation, while if poorly done or falsely regarded the later work will inevitably lack stability and permanence; but of itself alone—if it be not accompanied and followed by that for which it is a preparation—this rudimentary technique is practically valueless. Prizes and diplomas may be given to encourage, and as evidence of, its acquisition; but this does not alter the fact that it is no more than a preliminary to the real undertaking. A certificate of proficiency in the school work of engineering is not evidence of ability as an engineer; and if regarded as such, it will inevitably lead to disappointment for its possessor, and to dissatisfaction for others. It cannot properly be regarded otherwise than as a ticket of admission to the real study of engineering among the things of actual life in the world. As to what the holder will do in that real study, none can say; but at present it would seem that his subsequent achievement usually bears little relation to the endorsements upon his ticket of admission—and this reflects adversely upon our engineering school methods, for if the schoolwork were done always with the real work in view, excellence in the school work would of necessity indicate aptitude for the real work.

Unquestionably the evil lies, to a very great extent, if not entirely, in the unnatural attitude of detachment from simple, human reality which is so generally adopted; and it is unquestionable also that this attitude has been brought about largely through wrong methods of studying and teaching mathematics. The subjects of "pure" mathematics are taught always as supernatural matters which are of necessity incomprehensible to the human mind; and as relating to conditions which are impossible of realisation in a world which is irretrievably spoiled and degraded by the presence of human beings. The subject known as "applied"

mathematics is taught strictly as applications of this supernatural essence to things which have been freed, as far as possible, from the taint of human association. No attempt is made to bring even portions of it down to earth for mere human contemplation. The student must ascend (or, rather—which is far worse—must delude himself into a belief that he has ascended) to the higher planes to witness the applications; and he is unable to bring anything back with him on his return to earth.

Even in the quite modern subject of "practical" mathematics, the mystery of the supernatural is preserved; the main object being, apparently, to present a few cold fragments from the outer fringe of the incomprehensible, in a form suited to the limited intelligence of engineers and others who cannot hope to rise above that peculiarly benighted stage which is termed "practical." Even the units in which our pitifully rough measurements are taken have to be simplified for us by those who can bear to ascend the mountain on our behalf; but lest these poor simplified travesties of the incomprehensible "truth" should defile others, they must be carefully labelled as "engineer's" units—and perhaps those who purvey such dangerous commodities may some day be required to register the names and addresses of their clients, as with rat poisons and weed killers. It is more surprising that engineers should have tolerated such a state of affairs for so long than that they should now revolt against it and demand its replacement by something more rational and sportsmanlike.

To search back with the object of discovering the origin of this abstract view regarding mathematics might be interesting and instructive in some ways; but it would occupy much time and labour, with little prospect of real benefit, even were the search carried to a successful conclusion. The antiquity of the view is clearly evident from even a cursory study of the history of mathematics; while the works of such writers as Euler, Newton and Rankine show plainly that, so far from an alternative view being sought, there was no thought of need for another view—so strong was the grip of mysticism upon scientific matters.

Improvement is far more likely to be effected through patient and persevering endeavours to strip off the wrappings of mystery with which the simple truths of natural philosophy have been intentionally or unintentionally swathed. If the length of that line which is known as the sine of a given angle can be expressed, either accurately or approximately, in terms of the length of the arc which subtends that angle, it is quite certain that the argument through which the expression is deduced cannot contain any step or factor of a supernatural character, nor any process which has no physical counterpart within the comprehension of ordinary, normal human minds. Evasion of the difficulty by stating that complete tables are now available, and that therefore the argument need not be understood, does more harm than good; for it keeps the engineer still shut out from comprehension of things which he is called upon to use daily, and for the reliability of which he is held personally responsible. Verification of the tables by drawing particular cases to a large scale and measuring with a micrometer is useless, for it does not help towards that comprehension of the underlying realities which is vitally necessary for a proper use and control of the results. Testing the expression by inserting particular values in the terms of a series is worse, for it reduces the engineer to a mere operator, while emphasising his ignorance of the realities. This is but one of the many things which have tantalised and troubled us all more or less; and which we have had to swallow whole at last, still not understanding them, for the sake of passing examinations.

Engineering deals always and solely with actual physical realities; and the mathematics of engineering must be taught and studied throughout in terms of physical reality if the school work is to form a suitable foundation upon which the real education of an engineer may be built. That this may be done without difficulty, and that better results are thus obtained with much saving of time, are, as has already been stated, facts admitting of ready demonstration.

Mathematics must be taken out of the sealed glass cases in which its mummified remains are kept from contamination by practical use. Engineering is a game for sportsmen, and it must be played in a sportsmanlike spirit, with all the cards on the table. If some of the mummified remains fall to dust at the first breath of fresh air, so much the better; we shall know that they had none of that strong vitality which is essential in everything truly applicable to engineering. And if some of the wrappings, on the outside of which are painted delineations of their alleged contents, prove on removal to contain either nothing at all or something not in accordance with their advertisement, so much the better again; we shall know that precious time and energy need no longer be wasted in doing homage to the painted delineations.

The whole attitude towards the matter has been wrong. The view has been persistently inwards; whereas it should be consistently outwards. We have been making a few observations of fact, and bringing these with bated breath into the secret and mysterious chamber where the supernatural action of mathematics may refine them in a sort of witch's cauldron, and provide us with a "pure" solution in the shape of a formula which we may not hope to realise in mere simple fact. What we have to do is to reverse this procedure—to throw open the secret and mysterious chamber, that all may see how truly simple and natural are those operations and processes which have been made to appear mysterious and supernatural; and then to take these things out with us into the open fields of engineering. In a word, we must now control them, instead of continuing their abject slaves. And the encouraging aspect of this adventure lies in the fact that each properly-directed experiment in it not only yields a result satisfactory beyond expectation in its own particular field, but also reveals clearly many other things which appeared vague and incomprehensible before.

There is another matter in which engineering education to-day is wrong, both in the school work and in the individual self-education which follows it. The activities of the human mind may be classified under three broad headings: (1) imitative, (2) interpretative, and (3) originative. Such a classification is already recognised—tacitly, at least—but the fatal error is made of attempting to apply the classification to individual minds instead of to the activities of each and every mind. In such imitative work as the manufacture of ordinary sewing needles there is wide scope for the exercise of both the originative and interpretative faculties. In the essentially interpretative work of the ordinary commercial drawing office and machine shop there is of necessity much that is almost purely imitative, while there is also need for originative ability without in any way encroaching upon the preserves of design. And in the originative work of design, administration and organisation there is inevitably a great deal that is imitative, and also very much that is truly interpretative.

It would be difficult, if not impossible, to define precise boundaries between any two of these fields; and it would appear unlikely that any useful purpose would be served by such definition. All three should be cultivated and developed, with equal assiduity and care, in each and every mind—for all three are of equal importance—instead of endeavouring to produce here and there a few minds which shall give out original ideas constantly and exclusively; and a few others which shall do nothing but interpret the ideas originated by their superiors; while the main bulk are left to wallow in mere imitation. The latter course has been followed for a long time, and is now obviously found wanting—a result which is not surprising, seeing that the method is altogether unnatural.

It is, of course, true that the higher ranks of the profession are concerned with originative work to a greater extent than are the lower ranks; and that, consequently, personal progress in it must be upwards from work which is mainly imitative through that which is mainly interpretative. But no argument is needed to show that every individual member of it, as well as the profession as a whole, would benefit enormously were the fact recognised and made clear to all that, throughout life, the three faculties are all of equal importance in each mind, and should be cultivated and developed with equal care—that work which is apparently of the most imitative character demands the exercise of the interpretative and originative faculties if it is to be really well done; and that it is impossible for a man to originate any truly good project unless his imitative and interpretative faculties be thoroughly keen and well developed.

In conclusion, it is highly regrettable that no place is found in the ordinary curriculum of engineering for the cultivation of that vital necessity for a really practical engineer—self-respect. The bluster and bounce with which the ill-trained so commonly seek to hide their ignorance is obviously unworthy of an engineer—and is almost invariably detestable in his eyes. Students should be continually and effectively warned against this, and encouraged—with assistance of the most practical character—to acquire and prize that proper self-respect which can only be born of the certain and fully proven possession of complete command both of oneself and of the things dealt with. The average student would become a better engineer, and also a happier man, were he shown plainly that, while the due and proper performance of an allotted task is unquestionably a right object, there is also to be considered the effect of that action upon his own personality—that a good job well done has an influence upon his character, and brings with it a satisfaction, far beyond the mere recognition or remuneration accorded to it by others; while a job shuffled through in a half-hearted or slipshod manner will just as inevitably have its effect in the opposite direction. Moreover, these influences and effects are permanent.

RECOVERING FUEL FROM ASHES BY MAGNETIC SEPARATION.

THE presence of coke and unburnt coal in ashes often constitutes a considerable loss of fuel, and up to the present there has been no very effective method of recovering the combustible matter from the refuse. We are informed that Messrs. Fried Krupp, in Germany, have devised a magnetic separator for the purpose and that many of such machines are now in successful use. Practically all coals contain iron in the form of pyrites, which has no magnetic properties. The burning of the coal, however, converts the pyrites into oxides which are magnetic, and as the whole of the iron passes away with the slag the metal exists there in a very much more concentrated form than in the original coal. These facts are taken advantage of to effect the separation. The machine employed consists essentially of a magnetic drum over which the furnace refuse is passed. The drum rotates slowly about a horizontal axis, just as in the case of an ordinary magnetic separator. The ashes to be treated are delivered by a bucket elevator to a vibrating screen which separates them into various sizes. Each size is passed separately on to the circumference of the drum. The slags containing iron are held magnetically to the surface for a portion of the revolution, and then drop off into small wagons or other receptacles as the current exciting the portion of the drum which held them, is automatically broken. The coal and coke which may be present do not adhere to the drum, but leave its surface directly after contact with it, and fall into their own receptacles. It is said that lumps of slag up to 3-in. mesh will adhere to the drum and thus be eliminated from the fuel.

The magnetic separators are built in sizes capable of dealing with quantities of ashes ranging from ½ ton to 2 tons per hour. The fuel recovered by these machines can either be burnt under boilers by means of forced draught or it can be briquetted, both methods being in use. We are informed that about 90 magnetic ash separators are now in use in Europe and elsewhere, and that 50 more are on order. Among the users may be mentioned the Hungarian State Railways, who treat locomotive ashes by the method described. The agent for Messrs. Krupp in this country is Mr. W. Stamm, 63, Queen Victoria-street, London, E.C. 4.

DANISH DIESEL ENGINES.—According to recent statistics, there were, on May 1, 1922, altogether 133 Diesel-engined vessels of over 2,000 tons. Of these, 78, aggregating about 500,000 tons, were equipped with Diesel engines of the Burmeister and Wain system.

CHINESE AERIAL SERVICE.—Resumption of the Peking-Tsinan Aerial Service inaugurated in May, 1921, and suspended shortly afterwards, is again under consideration, says the Chinese Government Bureau of Economic Information. Orders issued by the President have been received by the Aeronautical Department and the Ministries of War and Finance to devise means to resume the service. The authorities of the Department have made an estimate of 350,000 dols. or thereabout as the necessary expenses for resumption of the air line.

THE TWIN-SCREW GEARED TURBINE CUNARD STEAMER "SAMARIA."

CONSTRUCTED BY MESSRS. CAMMELL LAIRD AND CO., LIMITED, SHIPBUILDERS AND ENGINEERS, BIRKENHEAD.

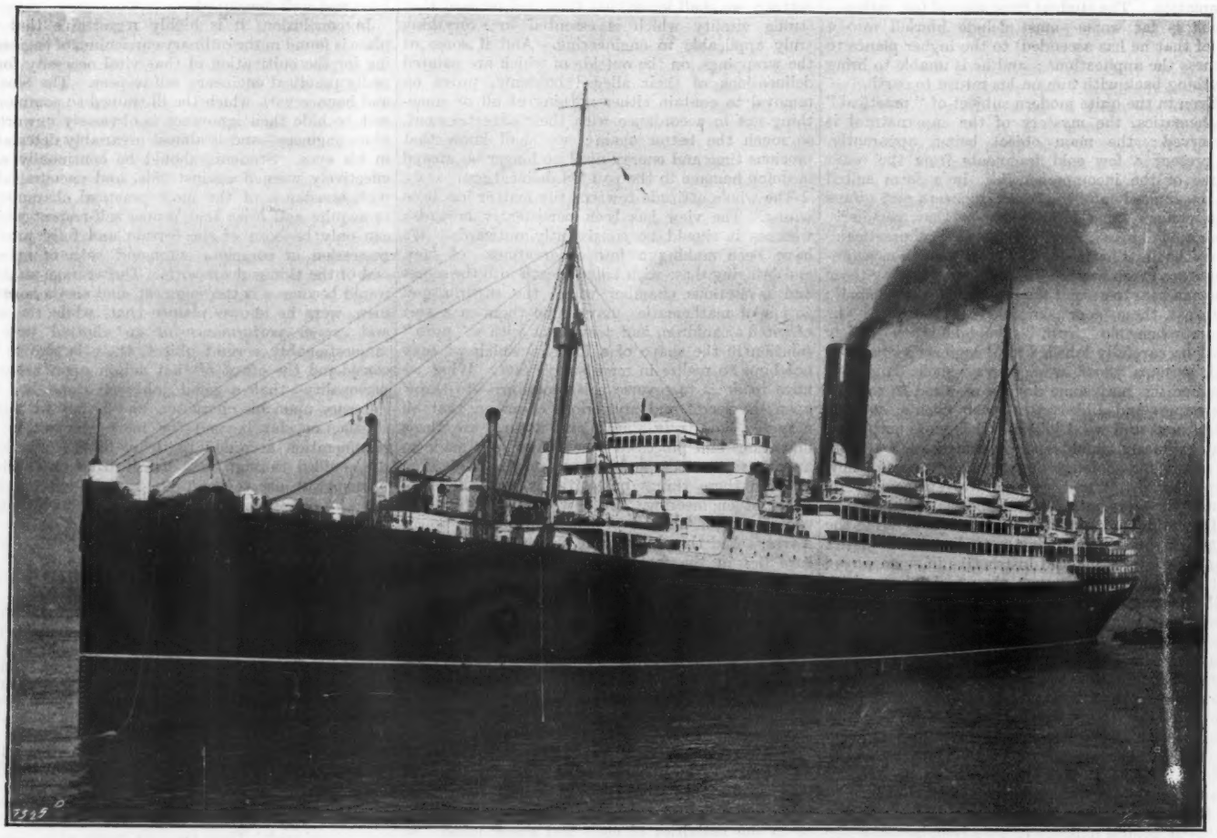


FIG. 1. THE SHIP AT ANCHOR.

SINCE the armistice the Cunard Steamship Company, Limited, have carried out an ambitious programme of building, despite the adverse effects of the troublesome conditions due to labour and other causes in the world of shipbuilding, and have received from the builders and put into commission no less than eight first-class liners. The company are to be congratulated on this notable achievement. Much of the successful issue of this enterprise is, of course, due to the officials of the line, and to a considerable extent to the enthusiastic endeavours of Mr. L. Peskett, the naval architect to the company.

The Samaria, which we illustrate on this and the opposite pages, on page 16 and on Plates I, II and III, is one of these eight vessels, and was constructed by Messrs. Cammell Laird & Co., Limited, of Birkenhead, and has the distinction of being the largest ship ever built on the Mersey. She is a sister of the Scythia, built by Messrs. Vickers, Limited, and of the Laconia, constructed by Messrs. Swan, Hunter & Wigham Richardson, Limited. These vessels, with the others, are all now engaged in the transatlantic services of the Cunard Company.

The main dimensions and other particulars of the Samaria are given in the following table :—

	ft.	in.
Length, overall	623	9
Length between perpendiculars ...	600	0
Breadth, moulded	73	6
Depth, moulded to shelter deck ...	45	0
Gross tonnage	20,000	
Displacement on 30 ft. draught ...	27,000 tons.	
Speed at sea	16 knots.	

The vessel was built to special survey to the highest class of Lloyd's Register, and to the requirements of the British Board of Trade and the regulations for passenger steamers of the United States of America, and her watertight subdivision and other safety equipment comply with the conditions laid down by the International Convention on Safety of Life at Sea.

The Samaria is propelled by steam turbines through double-reduction gearing, which will be described in a later issue. A shaft horse-power of 12,500 is divided between the two propeller shafts for normal full power, but an overload capacity up to 13,500 h.p. is available whenever necessary.

The general appearance of the vessel is well shown by Fig. 1, above, while a view of the deck, looking forward, is given in Fig 2, on the opposite page, and illustrations of the passenger accommodation are provided in Figs. 3 to 6, on Plate I, Figs. 17 to 20 on Plate III, and Figs. 21 to 24 on page 16. Plate II shows longitudinal and cross-sections and plans of the various decks in Figs. 7 to 16.

The Samaria has eight decks, four of which run from stem to stern. The passenger accommodation extends over seven of these decks, and forms a modern and luxurious hotel. In decoration and furnishing the Samaria is a criterion of the high standard, in elegance, luxury and comfort, which has been attained in the boats on the transatlantic service. The illustrations on Plate I and on page 8, showing some of the first-class public rooms, special suites and cabins, bear out this contention, while those of the second-class, given on Plate III, show a distinctive note of comfort, which is characteristic of what is found only in the best types of ocean liners of to-day. There is provision for 2,181 passengers, of whom 323 are first-class, 436 second-class and 1,422 third-class.

The first-class public rooms are all very spacious and lofty, and are directly approached from the central hall. The lounge (Fig. 3, Plate I) is oval in shape, and has four alcoves, and is provided with a central dome of white glass in the roof; all the ornamentation is carried out in stucco, and is of the Empire style. A marble mantelpiece over a tiled fireplace has a picture belonging to the period, the latter part of the eighteenth century, surmounting it. The decoration of this lounge provides a most effective colour scheme in black, grey and gold, in contrast with the antique mahogany furniture. Coverings of Chinese style, and harmonising curtains, complete the rich ensemble.

The main feature of the drawing- and writing-rooms, which are combined, is a central elliptical dome in the roof, having a fan-shaped painted panel on two sides. The scheme of decoration is that of the eighteenth century, and is carried out with white walls and ceiling, Adam furniture in antique mahogany, and coverings in purple and yellow. Damask curtains and a rich purple carpet complete the scheme.

The first-class dining saloon (Fig. 5, Plate I) extends the full width of the ship on deck E (Fig. 14, Plate II), and has a length of 64 ft. There is a musicians' gallery, a large central pierced dome, and a most attractive scheme of lighting, the dome partially concealing the brilliant electric globes, whose light penetrates through the piercings. An oval buffet in the centre and small sideboards in various parts of the saloon are useful in maintaining prompt service to the diners, who are accommodated at tables for two, four, or six.

The smoking-room (Fig. 6, Plate I) is panelled in antique oak, and furnished in plain Chippendale, with large settees and easy chairs covered in Chinese tapestry, after the style of the early eighteenth century needlework.

There are two private suites on deck B (Fig. 11, Plate II), each consisting of vestibule, sitting-room, bedroom, and bathroom. The decoration is in the Louis XVI style. Green and gold provide the colour scheme of the sitting-rooms (Fig. 21, page 8), which are fitted with a vert d'Estours marble mantelpiece, surmounted by Lancret pictures of Spring and Summer. An Ormolu firegrate is a feature in each of these rooms, which are lighted with four large windows, and furnished with settees, chairs and side tables. French grey and white are used in the treatment of the bedrooms (Fig. 22, page 16), which are arranged to provide the maximum amount of convenience and wardrobe accommodation. It is possible to cut off these special suites entirely from the general accommodation, if desired at any time, when access would be obtained by private vestibules. A number of *en suite* staterooms, with bathrooms, are provided, and are attractively decorated in dado panelling, with chintz and silk curtains and coverings.

The second-class dining saloon (Fig. 18, Plate III,

TWIN-SCREW TURBINE CUNARD STEAMER "SAMARIA."

CONSTRUCTED BY MESSRS. CAMMELL LAIRD AND CO., LIMITED, BIRKENHEAD.

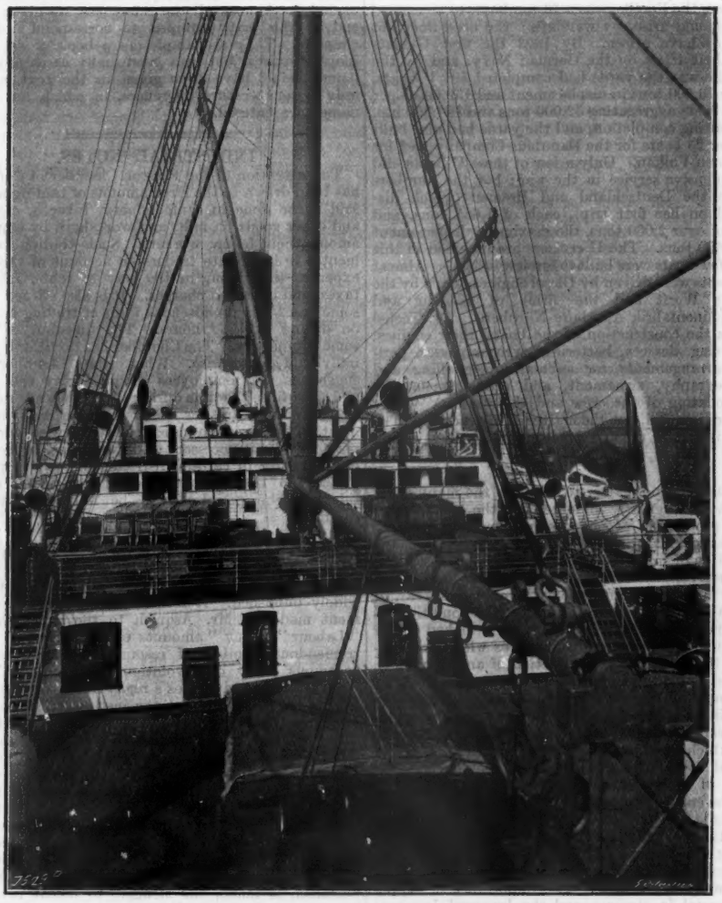


FIG. 2. VIEW FROM AFTER DECK LOOKING FORWARD.

has small tables for four or six persons, and small service tables instead of the usual sideboards. Mahogany furniture and moquette-covered chairs and settees, with a carpet to match the upholstery, are used in the lounge (Fig. 18, Plate III). Oak panelling is fitted in the smoking-room (Fig. 19, Plate III), and the furniture is of the same wood; the upholstery is of moquette, while the floor is covered with Jaspe rublino tiles of octagonal pattern. The verandah café for the use of second-class passengers overlooks the stern of the vessel, and thus has an uninterrupted view aft and, at the same time, a sheltered view.

A distinct advance in third-class accommodation in the Atlantic service is to be noted in the Samaria. There are two large dining saloons, a public room and smoking room, and ample open and covered promenade space. The sleeping accommodation consists of two- and four-berth rooms, separated by spacious alleyways. All these rooms are commodious, well lighted and well ventilated.

The crew have comfortable quarters, on decks D, E and F (*see* Figs. 13, 14 and 15, on Plate II), with up-to-date galvanised berths, separate messrooms for the various sections, electric light, and Thermotank ventilation, fitted in accordance with all the requirements of the British Board of Trade, and the U.S.A. authorities.

Four hospitals are provided, two for ordinary cases, and two for infectious diseases, as well as a dispensary and an operating room.

The kitchen arrangements are of the most modern description, and every mechanical and electrical device to reduce labour has been installed. Potato-peeling machinery, apparatus for mincing and slicing, and steam ovens form part of the equipment. The bakery is fitted with the latest dough-mixing machines, and with water-tube ovens. Meals can be served with despatch and efficiency through the use of the fitments in the many pantries and service rooms. These devices include hot presses, coffee-making apparatus, electric toasters, and dish-washing machines.

All passenger accommodation above the bulkhead deck is divided up into sections by fire-proof partitions, which are provided with hinged doors made of mahogany which has been rendered fireproof.

There are two steel pole masts, which carry eight three-ton tubular steel derricks, and six derrick posts, with three-ton steel derricks working on them. Over the hatches cargo spans are arranged, which are provided with four gin blocks each. Welin's quadrant davits are used to lower the lifeboats, which provide accommodation for everyone aboard, and are constructed to the latest Board of Trade requirements. The deck machinery, such as the capstan, windlass and the winches for warping, cargo and the boats, and the steering gear, are of the electric-hydraulic type. A telemotor gear, actuated from the navigating bridge, is used to operate the steering gear, but there is also an alternative control by mechanical means from the after-deck bridge. In addition to the standard magnetic compasses, a Sperry gyro compass outfit is provided, consisting of a master instrument below deck, which controls three compasses on the bridge. A complete and powerful Marconi wireless installation assures the possibility of communication with the shore stations in her vicinity, and with vessels on the high seas.

The arrangements designed to extinguish fire in the hold and between decks comprise the steam piping requisite to meet the requirements of the Board of Trade, but, in addition, means are provided for the injection of carbon-dioxide gas into these compartments, and also to the boiler room through the same pipe system. Carbon-dioxide possesses valuable properties compared with steam or water in coping with a fire, notably in its great power of permeating the whole of the contents of a cargo hold or a bunker, and in being entirely non-injurious to any kind of cargo. The carbon-dioxide plant installed is of the "Gronwald" type, and was supplied by the New British Ship-fire Protection Company, of Cardiff. It consists of cylinders containing the gas, and steam chambers in which the gas is expanded before it is passed into the steam pipes of the compartment. Each whole unit is portable, and can be carried to the place where it is required.

The permanent fire-extinguishing pipes are brought to deck plates at six stations in the working passage on the deck D. The carbon-dioxide plant is connected, when required, through a valve to the pipe supplying steam to the Thermotanks of the ship's heating systems to obtain its steam supply. After all the hatches and other openings to the space where a fire may be located are closed, connection is made to the deck plate by means of metallic hosepipes, and the carbon-dioxide is injected into the compartment. The flow of the gas is entirely due to its own pressure. The hold can soon be filled with carbon-dioxide, and the fire extinguished; the presence of the gas ensures not only that there will be no further outbreak, but that the goods will cool down.

(To be continued.)

NOTES ON NEW BOOKS.

A BOOK on materials for boiler construction, which is at the same time a dissertation for obtaining the degree of Dr. Ing. from a technical high school, is probably a novelty. The scientific treatment, which we may expect from a dissertation, offers a certain guarantee that commercial interests will not obtrude themselves. There is, indeed, in Dr. Ing. Kurt Meerbach's "*Werkstoffe für den Dampfkesselbau*" (Berlin: Julius Springer; price 6*s.* 3*d.*) nothing to remind the reader of the iron works with which the author is connected, excepting the statement in the preface that the volume (of 198 pages, octavo) is based upon the experience which he has gained as director of the rolling mills of the Rothe Erde works, near Aachen, and references to special researches conducted in the works. The three sections of the volume deal with the casting and rolling of the ingots, the making of the boiler, and the mechanical, thermal and chemical conditions to which the boiler will be exposed. The author's object is to instruct boiler makers and engineers on the properties and suitable treatment of the material and products—all in plain language; mathematical formulæ are more scarce than references and illustrations. The photographic reproductions are excellent, thanks largely to the good paper. We notice, for instance, photographs of the distribution—surprisingly uniform—of cementite in a block which, owing to some mishap, had to be kept in the furnace for three days and which finally rolled down to very good plating. Noteworthy also are the illustrations of blow holes and slag enclosures, and, further, the curves and figures illustrating experiments by Dr. Meerbach and Kuster on the temperature distribution in ingots when cooling in moulds of various sections, rectangular, with sides of different lengths, or elliptic. When the mould was purposely cooled on one of the small surfaces or exposed to the wind, the temperature curves were altered, and the zones of segregations were shifted towards the warmer side. One-sided cooling, especially of several moulds arranged in a row, should be avoided.

The application of grinding operations in industry has become so extensive and varied that there is scarcely any manufactured article of commerce which does not receive some form of treatment with abrasives during its production. In the engineering industries the extension of grinding during recent years has been on a gigantic scale. Quite apart from the production of articles true to size within minute limits, there is a large field for those operations in which rougher work formerly done in shaping, slotting and planing, and other cutting types of machines may be accomplished with economy. With the changed outlook in engineering and other industries the demand for all types of abrasive products increased enormously. A knowledge of the materials used in the manufacture of grinding wheels, stones, blocks, papers, cloths and polishes, and the treatments they undergo in the process of production is necessary to every man who has to decide what shall be used in any particular work. Mr. Alfred B. Searle has written a primer on this subject under the title "*The Manufacture and Uses of Abrasive Material*," which has been included in Sir Isaac Pitman and Sons' well-known technical series, and is sold at 2*s.* 6*d.* net. To those who have not acquired specialised experience in the process of grinding there is presented in this small book a large amount of information, which will prove of great value when they are confronted with grinding problems. The various materials employed have strongly differing characteristics, and these are discussed as well as suitable speeds and the class of work for which each is suited. The erection and actual

operation of the machines and wheels is the subject of a chapter in which the mounting, the truing and dressing of grinding wheels and the avoidance of poor cutting, glazing and burning are discussed in such a way as to provide the essential information in a single chapter. This little book will be much appreciated by those who desire general information and conclusions on the various phases of this most important industrial process.

The determination of the amount of water, passing down a river or conduit, is still a matter of difficulty. Measurement of the total bulk being generally out of the question, we have usually to content ourselves with determining the rate of flow at certain points or through certain limited cross-sections, and we do this by means of various instruments, most of which are little more than modern modifications of ancient or old devices. Cabeo's vertical floating rod goes back to 1600 and the Pitot tube to 1730. Since the flow is not uniform, particularly in technical apparatus where cross-sections and current directions are apt to vary, back pressures are set up, and determinations have to be made at several points to arrive at a fair average value. The new grid current-meter (Messgitter) of Oskar Poebing, chief of the Hydraulic Institute of München, is one of the instruments which aims at giving a continuous record of the average rate of flow. The grid consists of 30 wooden rods or laths, 1,340 mm. by 48 mm. by 14 mm., so mounted in a framing that the whole grid rests vertically on two knife edges, being balanced by weights. The water current tends to deflect the grid, which is pulled back into its normal position by means of springs, and the force on these springs is recorded on a rotating drum. There are various damping devices. The construction of the grid, its calibration and its performance under various conditions, together with a critical historical review of water-current meters, are explained by Poebing in an octavo volume of 55 pages, under the title "*Bestimmung strömender Flüssigkeitsmengen im offenen Gerinne*" (Determination of Streaming Fluids in Open Conduits. Berlin: Julius Springer; price 2*s*.) Poebing finds that his grid meter will, in spite of turbulence, give records reliable within 2·5 per cent. for average rates of flow of about 300 litres (66 gallons) per second. The instrument causes only a very slight loss of head and is hence recommended particularly for low-pressure hydraulic plants. The meter was tested, however, under widely-varied conditions of head and back pressure, for rates of flow up to 1,500 litres per second, and also with special regard to the pulsation theory of water flow of the late Professor Camerer, formerly director of the München Hydraulic Institute, which just before the war was being equipped on what was an unusually complete scale.

The shortcomings of many books are found at a time when the possessor is seeking for definite and usable information on some point in a hurry. How often is it the case that the matter available proves inadequate? General statements of principles may be dealt with quite fully, but the application to actual conditions is rarely treated in anything like the way the reader hopes for. It is for this reason that such a work as that of Eugène Marec on "*La Force électrique dans l'industrie*," published by Gauthier-Villars et Cie, of Paris, at a price of 55 francs, must be welcomed. There are few works in which lucidity of treatment and emphasis of the important characteristics of electrical machines and their applications are combined with such effect. Unlike what is found in many books on this subject, guidance is here provided in the actual installation of the plant and in the general organisation of a scheme for the electrical equipment of a works. The information necessary for the selection of a suitable system for any given conditions of running, from the standpoints of adequately meeting all the power requirements and of ensuring low maintenance and power charges, is quite unusually full. There is a discussion of the comparative economy of taking public supplies or installing a complete generating plant. Much information is given on sub-stations and their equipment. The transmission of electricity by cables, underground and overhead, its control at transforming or distributing points, and at places of application, the starting and speed regulation of the various types of electric motors and the use of special windings and electrical or mechanical devices to meet the requirements of particular control problems are all dealt with in this eminently practical, well written and illustrated book.

Parts of the story of the construction of submarines by the Germania Werft, as told by Dr. Ing. H. Techel in his monograph on the "*Bau von Unterseebooten auf der Germaniawerft*" has already appeared in the columns of the *Zeitschrift des Vereines Deutscher Ingenieure* in various articles spread over the years 1919 and 1920. As now supplemented the monograph forms a small quarto volume of 100 pages illustrated by 380 text figures, diagrams and plates. (Berlin: Julius Springer; price for England, 5*s*.) On the suggestion mainly of one of the Krupp engineers, Herr d'Equevilley, the Germania Werft took up the construction of submarines in 1902, very soon after the shipbuilding yards had been acquired by the firm of Friedrich Krupp, of Essen. The first experimental submarine, the Forelle, was a 16-ton boat, to be carried if need should arise, by warships; the need does not appear to have arisen. By 1903 the first U-boats passed their trials by the German Navy, and by the end of the war the yards had completed 101 U-boats, totalling 76,500 tons in displacement and 159,000 h.p.; 35 more boats aggregating 52,000 tons and 124,300 h.p. were awaiting completion, and the yards had also built altogether 25 boats for the Danubius Company and for the Bremen Vulkan, Only a few of these U-boats did actual offensive service in the war; but the numbers comprise the Deutschland and Bremen (which disappeared on her first trip), each of 1,685 tons, and 5 boats of over 2,000 tons, the maximum displacement being 2,600 tons. The U cruisers are included in this list. A few boats were built to foreign orders. Almost all the boats were driven by Diesel engines, made by the Germania Werft and the firms of Körting and the Maschinenfabrik Augsburg-Nürnberg. Dr. Techel describes the construction of the boats, their engines, manœuvring devices, batteries, gyrocompasses, periscopes, arrangements for submarine signalling and radio-telegraphy, armament, and provisions for the accommodation of the crew and their safety. Some details are omitted, but the matter is instructive. The volume is not a popular book on submarines in any sense.

The engineer, no matter to which of the many types he belongs, is greatly indebted to the metallurgist for the production of changes in the stress-resisting properties of materials by heat treatment and the introduction of small proportions of various substances. When new conditions of use and new applications of common materials are necessary the excessive wear, or structural weakness of the metal for the conditions is early apparent, and the metallurgist is looked to for information as to available substances which are suitable for the work or the production of an alloy which will stand up to the conditions. At some stage in the development of almost every metal article a problem of this kind has been found and in many cases solutions have already been effected. Molybdenum is one of the metals which have proved of service in the production of special steels for many purposes of engineers. The function of molybdenum in the complex alloy steels is to prevent segregation and crystallisation of the constituents and thus promote uniformity of texture. This metal is of great importance in the production of steels for motor car construction, linings of big guns, rifle-barrels, armour-plate, armour-piercing projectiles and in many other ways. The importance of supply of this metal is obvious, and the Imperial Institute asked Dr. R. H. Rastall to prepare a monograph on the subject with the title "*Molybdenum Ores*," which is published by Messrs. John Murray at 5*s*. net. In this work the author deals with the occurrence, character and uses of the metal and the sources of supply of the ores both within and outside the British Empire. Statistics of yields from the ores and the amounts mined, as far as these are available, are given, as well as a very complete bibliography of the subject.

When Dr. Wilhelm Hort brought out the first edition of his work on vibrations in 1910, there was, apart from Rayleigh's theory of vibrations, probably no book dealing with the whole domain of the technically important phenomena of vibrations, mechanical and electrical, in a general way. Since then, lectures on the general theory of vibrations have been provided for in several quarters, and what was before a special treatise has, in the second edition, become a text book. The *Technische Schwingungslehre* of Dr. Ing. W. Hort, chief engineer to the turbine works of the Allgemeine Elektrizität Gesellschaft and lecturer at the Berlin Technical High School, now forms an octavo volume of 828 pages, illustrated by 423 test figures. (Berlin: Julius Springer; price 24*s*.) Though the book is much enlarged and largely re-written, Dr. Hort adheres to his original plan not to start with a general theory, but rather to give definite technical examples from the beginning, and to show how the problems can be reduced to linear differential equations. Thus Chapter I deals with the simple undamped oscillations of the pendulum, the magnetometer and galvanometer; Chapter II introduces damping; Chapter III discusses forced vibrations; and Chapter IV passes to instruments for recording vibrations, indicators, seismographs, oscillographs, vibration galvanometers, kinematograph, &c. It would have been better to have begun with Chapter V, on mechanics. Oscillations with one and several degrees of freedom, oscillations of elastic solids, of liquids and gases, gyroscopes, coupled vibrations, electromagnetic vibrations in conductors and in space, &c., form separate divisions. Each of these divisions stands, more or less, by itself, and one might feel disappointed by matters apparently omitted, if the good index did not facilitate looking up cognate information. Much detail had, of course, to be excluded. Almost all the references are given at the end of the text, grouped to correspond with the chapters. They are ample, as a book of so vast a scope requires, but in a good many cases prominent names should have been given in the text, and not only in the literature references, in which not all the names are entered.

INDUSTRIAL NOTES.

THE attention of the Preston Chamber of Commerce has been drawn to the large amount of trading which is said to be done in confectionery, tobacco, cigarettes and other goods, in mills and workshops by employees among their fellow workers. Such trading is detrimental to legitimate traders on account of the heavy expenses they incur in the way of rents, rates and taxes, and overhead charges. It is also alleged that in some cases this promiscuous form of trading is carried on during working hours. The question is one of some complexity. The Chamber has no title to restrict individual enterprise. What the Chamber does suggest is that employees should "play the game" and not utilise the time during which they are supposed to be working, and for which they are receiving payment, in the direction indicated. Otherwise, employers may consider it necessary to do what has, in fact, been done already in certain districts, namely, to post up notices to the effect that employees found making sales on the premises will be liable to summary dismissal.

The fortieth annual report, for 1922, recently issued by the Liberty and Property Defence League, contains a large number of facts which might very well be widely published. It recalls, for example, the statement made by Mr. Asquith to the effect that the "Labour" policy "amounts to nothing more than a tremendous number of resounding phrases and an enormous array of revolutionary expedients." The report, further, advocates a really national propaganda having for its sole object the instruction of people in economic truth; this, it adds, is the great need of the times. Those who hold fast to the principles of individual freedom, private property, and personal initiative have, so far, allowed the enemies of their social and political faith to wage war upon civilisation without any organised attempt at resistance worthy the name. Although, for the moment, the danger is not immediate, there can be no manner of doubt, according to the Council of the League, that unless an effort commensurate with the magnitude of the menace of Socialism is made, the struggle to defeat revolution later on may prove itself too formidable. Preparation for the conflict that must come should, it is urged, be made now, and a systematic and persistent propagation of economic truth on a scale that the circumstances so insistently demand, is to be undertaken by the League in the homes of the people who are being continually preached to by the opposite party.

The European manager of *The Iron Trade Review*, Cleveland, Ohio, has recently returned from Germany, where he interviewed leaders in the iron and steel industry. This personal investigation, says the American journal, indicates that reports of Germany's impending collapse are grossly exaggerated. Whilst the financial situation in Germany is very serious, economic conditions reveal some favourable factors along with the unfavourable, tending towards the conclusion that Germany can work out her own salvation. Iron and steel production in Germany is slowly improving and plants are busy with orders booked three or four months ahead. There is no unemployment at iron and steel plants, the situation everywhere being much improved. The railways are in better physical shape than at any time since the end of the war.

Mr. S. W. B. McGregor, H.M. Senior Trade Commissioner for Australia, calls special attention to the Australian market, and adds that the United Kingdom's present share in that market will not be retained without severe competition from the United States and possibly other countries. The Queensland loans recently raised in New York and now standing at a considerable premium, together with offers made by United States financiers of loans to the other States, are an indication of what may be expected, apart from competition in prices of goods and sales organisation. In textiles the position of the United Kingdom is supreme; the weakness of her position is particularly in machinery, engineering and the allied trades. In these, the United Kingdom has to face competition from local manufacturers as well as very severe competition from the United States, and possibly German

competition will be felt in the near future. The best products, the best sales methods, the best type of representatives are not too good for the existing valuable Australian market with its vast future possibilities.

A manifesto has recently been issued by the Trades Union Congress General Council. Among other things, it says that owing to chronic unemployment the wage bill of the country has been reduced by 13,000,000*l.* per week, or 676,000,000*l.* per year. "This enormous reduction in the purchasing power of the worker has, in its turn," the statement adds, "diminished the demand for labour." The manifesto further states that "the development of international trade has been retarded by our Government's continued adherence to a foreign policy which prevents the reopening of our international trading relations.' Further, the employers are accused of reducing wages; as regards fundamentals this statement is untrue, since it is really the consumer who reduces wages, by refusing to purchase a product which he finds too expensive. The fact that we live largely on imports is always ignored. A farmer, in South America for instance, will not give more meat or corn in exchange for our manufactured products than he did formerly; if our price for these latter is too high he will not make the exchange and there is no trade. The saddling of Government with the responsibility is simply futile. Taken as a whole the manifesto adds to the "tremendous number of resounding phrases" mentioned in the foregoing.

As we stated in a former issue, the Welsh ports are congested, since the loading of coal-carrying ships cannot proceed with sufficient rapidity. A meeting of representatives of shipowners and trimmers was held at Cardiff at the end of last week, and although this is a matter of great urgency which affects the whole trade of the country, no decision was arrived at. It was simply stated at the close that early in the present month a conference would be held "of the various interests concerned to consider the question of the introduction of a third shift at the docks."

We are informed that the Ebbw Vale works' dispute, which had lasted many weeks and had led to the closing down of the whole plant, has now been finally settled, a new agreement, based on a price list made by award of the arbitrator, Dr. Galloway, having been entered into by the Ebbw Vale Company and their men. The company are making every effort to start the plant afresh at an early date.

TRAFFORD PARK.

THE story of the successful development of the estate of the de Trafford family into a great industrial district is well told in a book issued by the Trafford Park Estates, Limited, entitled "Britain's Workshop and Storehouse." The potentialities of a large tract of land beside the Manchester Ship Canal were early seen by men of progressive outlook in that city, and the demand they made for sites in positions suitable to obtain the expeditious and cheap transport afforded was met by the purchase and laying out of Trafford Park. Much of the success achieved must be credited to Marshall Stevens, the chairman of the company. Transport facilities, warehousing and cold storage accommodation were soon provided and the number of works continuously increased until two-thirds of the available 2 square miles is occupied. The cutting of charges in the handling of goods and their transport to the place of use is of great importance, and this book, which is well illustrated with maps and photographs, gives information regarding the facilities provided at Trafford Park, which account for the popularity it enjoys as an industrial district, with manufacturers.

ELECTRICAL SHOT-FIRING.—Wherever it is feasible to adopt electrical shot-firing for either mining or quarry work, this should be done as a safety measure, states L. C. Ilsley, electrical engineer, of the United States Bureau of Mines. Electrical shot-firing, when properly carried out, eliminates some of the inherent dangers of fuse and squib firing. Several States have already, by regulation or enactment, covered the question of electrical shot-firing, and the Federal Operating Regulations, under the Land Leasing Act, make provision for firing from the surface.

"NORRLAND."—The General Export Association of Sweden has recently published an illustrated pamphlet in English dealing with Norrland, the land of forests, waterfalls and iron mountains, by Dr. Hans. W: son Ahlmann, reader in geography at the University of Upsala. Swedish Norrland is the district farthest north of any part of the world where industrial and economic life flourishes. It has an area of 100,850 sq. miles, with a population slightly over 1,000,000. It is rapidly becoming industrialised, owing to water transport facilities from the forests to the coastal sawmills, and abundant water power for generating electricity. The pamphlet gives interesting data on forests, waterfalls and iron-ore deposits in that part of Sweden.

"THE CORRECT INTERPRETATION OF MICHELL THRUST BEARING EXPERIMENTS."

TO THE EDITOR OF ENGINEERING.

SIR,—The importance of employing dimensionally correct expressions in connection with problems relating to oil film lubrication occasionally escapes attention, and a typical example occurs in a recent article,* by Mr. H. T. Newbigin, describing the results of some tests carried out on a small experimental Michell thrust bearing. This form of bearing provides one of the few instances in practical lubrication problems where theory and practice agree within reasonable limits, and in the course of the article a comparison has been effected by means of the formula:

$$R = 0{\cdot}0332\ \sqrt{\lambda \,.\, U \,.\, P} \quad . \quad . \quad (1)$$

where P and R represent pressure and shear force, respectively, in pounds per square inch, U represents rubbing speed in feet per second, and λ represents viscosity in C.G.S. units.

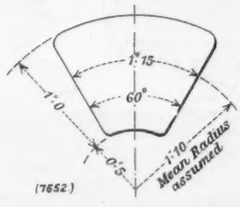
This comparison, being quite satisfactory, has apparently been accepted without questioning the validity of the formula employed. It should be obvious, however, that since P and R represent forces per unit area instead of per unit run, the above expression is dimensionally incorrect, and is, in fact, only strictly applicable to experiments carried out with one particular size of block. That this size should very nearly correspond with that actually employed in the experiments is a curious coincidence which affords some excuse for the empirical character of the formula being overlooked.

The dimensional discrepancy is directly attributable to a misinterpretation of the mathematics in Michell's investigation on this subject,† equation (1) being directly derived‡ from the following formulæ obtained by Michell for a square surface:

$$C^2 = \frac{0{\cdot}0214\ \lambda \,.\, U}{P} \quad . \quad . \quad . \quad (2)$$

$$-\frac{R}{P} = \mu = 10{\cdot}83\ C \quad . \quad . \quad . \quad (3)$$

where C represents the inclination of the surfaces and the other terms in C.G.S. units correspond with those given previously. When combining these formulæ to obtain equation (1) it should have been noticed that equation (2)



appears in a non-dimensional form. This is due to the fact that Michell for mathematical reasons made the length and breadth of the surfaces multiples of π and then treated this term as a purely numerical quantity. The missing length dimension is therefore included in the constant 0·0214.

The dimensions of the square surface considered by Michell were π by π, and equation (2) might equally well have been expressed in the numerically identical and perfectly dimensional form,

$$C^2 = \frac{0{\cdot}067\ \lambda \,.\, U}{P \,.\, \pi} \quad . \quad . \quad (4)$$

the π term in the denominator here representing the length of the surface in the direction of motion.

The corresponding formula for a square surface measuring L by L then becomes,

$$C^2 = \frac{0{\cdot}067\ \lambda \,.\, U}{P \,.\, L} \quad . \quad . \quad . \quad (5)$$

and is the expression which should have been used for the derivation of equation (1).

Michell pressure distribution diagrams have been reproduced in many articles dealing with this subject, and it might be noted that the alteration in size from π to L, while not affecting the actual shape of the curves, automatically involves the multiplication of all pressures by the factor $\frac{L}{\pi}$.

To indicate that this transformation is perfectly logical it need only be mentioned that Osborne Reynolds§ and H. M. Martin‖ have shown that the total load capable of being carried per unit of transverse length is given by

$$\frac{W}{b} = k \,.\, \frac{\lambda \,.\, U}{C^2} \quad . \quad . \quad . \quad (6)$$

where W is the total load, b the transverse length, and k a constant depending upon the geometrical shape of the surface and the film thickness ratio at inlet and outlet. That is to say, provided the film thickness ratio and slope remain constant, all surfaces of similar shape will support equal loads per unit of transverse length.

In the case of a square surface measuring L by L, $W = P \,.\, L^2$ and $b = L$, whence

$$C^2 = k \,.\, \frac{\lambda \,.\, U}{P \,.\, L} \quad . \quad . \quad . \quad (7)$$

which is identical with (5), if the appropriate numerical value for the constant k is inserted.

For the general case of a rectangular surface measuring L in the direction of motion and b transversely, $W = P \,.\, L \,.\, b$, and $C^2 = k \,.\, \frac{\lambda \,.\, U}{P \,.\, L}$ as before.

This alteration of dimensions can be shown to have no effect upon the coefficient of friction as given by equation (3), provided that the geometrical shape of the surface is unaltered.

The correct form for equation (1) is therefore obtained by eliminating the term C from equations (3) and (5).

This gives

$$R = 2{\cdot}8\ \sqrt{\frac{\lambda \,.\, U \,.\, P}{L}}\ \text{in C.G.S. units} \quad . \quad (8)$$

or

$$R = 0{\cdot}037\sqrt{\frac{\lambda \,.\, U \,.\, P}{L}}\ \text{in English units} \quad . \quad (9)$$

i.e., R and P in pounds per square inch, U in feet per second, L in inches and λ in C.G.S. units.

The blocks used in the experiments referred to previously were shaped as shown in Fig. 1. The revolutions per minute being 1,400 and the rubbing speed 13·44 ft. per second, it appears that a mean radius of 1·10 in. must have been assumed. This makes L equal to 1·15 in.

Taking this value for L, revised values for the shear force have been calculated from (9), and are shown in the following table:—

P Lb. per Sq. In.	U Ft. per Sec.	λ C.G.S. Units.	R. Lb. per Sq. In. Experiment.	Revised. $0{\cdot}037\sqrt{\frac{\lambda \,.\, U \,.\, P}{L}}$	Original. $0{\cdot}0332\sqrt{\lambda \,.\, U \,.\, P}$
187	13·44	0·260	0·90	0·88	0·85
373	13·44	0·197	1·09	1·085	1·04
560	13·44	0·170	1·136	1·235	1·19
746	13·44	0·152	1·325	1·350	1·295
1,000	13·44	0·130	1·515	1·440	1·315

As will be evident by comparing the revised and original figures the agreement between theory and experiment is actually improved. This is to some extent remarkable since the theoretical formula refers to a square surface while the actual surfaces experimented upon were segmental. Disregarding this difference, however, it is clear that the very close agreement obtained in the first instance is due to the pure coincidence that $\sqrt{\frac{0{\cdot}037}{L}}$ happens to be practically identical with 0·0332. Had larger surfaces been employed it appears probable that unsatisfactory agreement would have drawn attention to the fictitious character of the original formula used for comparison purposes.

When using segmental blocks the value of the length L is obviously dependent upon the assumption of a mean radius, and it would appear preferable to eliminate this term altogether from equations (8) and (9).

This can easily be done by putting $L = r\,\theta$, and $U = \frac{2 \,.\, \pi \,.\, r \,.\, N}{12 \times 60}$, where L is the mean transverse length, r the assumed mean radius in inches, θ the angle subtended in radians, and N the revelations per minute.

The formula (9) then becomes,

$$R = 0{\cdot}00346\ \sqrt{\frac{\lambda \,.\, N \,.\, P}{\theta}} \quad . \quad (10)$$

which is still dimensionally exact.

In conclusion it is only necessary to congratulate Mr. Newbigin on the close agreement between theory and practice in the very interesting experimental investigation that he has carried out.

Yours faithfully,
R. O. BOSWALL.

Manchester, December 16, 1922.

"THE DETERMINATION OF THE CALORIFIC VALUE OF LIQUID FUELS."

TO THE EDITOR OF ENGINEERING.

SIR,—Owing to the holidays, I have only just seen the letter of Mr. Thomas in your issue of December 22, and hasten to acknowledge the information given therein. The petrol vaporiser was attributed to Professor Watson under the impression that the design was due to him while the determinations of calorific values given in the joint paper of Thomas and Watson were by Mr. Thomas. I regret that Mr. Thomas' share of the work should have thus been unwittingly deprecated.

Yours sincerely,
Air Ministry Laboratory, S.W. 7. H. MOSS.

THE BIRCHILLS POWER STATION AT WALSALL: ERRATUM.—With reference to our note on the above power station on page 769 of our issue of December 22 last we are asked to state that the quantity of water required to maintain the water level in the upper canal at the above station is 550,000 gallons *per hour* and not *per day*, and similarly the amount pumped may be raised if desired to 1,200,000 gallons *per hour* and not *per day*, as printed.

* Michell Bearing "Lubrication Tests." H. T. Newbigin. ENGINEERING, September 1, 1922.

† "Lubrication of Plane Surfaces." A. G. M. Michell. *Zeitschrift fur Mathematik und Physik*. 1905.

‡ "Science and Art of Lubrication." H. T. Newbigin. Liverpool Engineering Society, December, 1919.

§ "Theory of Lubrication." Trans. Royal Society, 1886.

‖ "Theory of Michell Thrust Bearing," ENGINEERING, February 20, 1920.

THE PROPOSED MID-SCOTLAND SHIP CANAL.

AT many times and for many reasons the project of joining the east and west of Scotland by a canal of proportions suitable for the largest classes of vessels has engaged public attention and aroused a growing interest which later collapsed. Periods during which little was heard of the scheme followed, until enthusiasts revived the proposal with a view to providing a solution of some pressing problem of the day.

There were thoughts of cutting through the country with a canal early in the seventeenth century, and Alexander Ross in his "Notes on the Formation of the Caledonian Canal," published in the Transactions of the Gaelic Society of Inverness (vol. xiii, 1886–7), refers to Coinneach Odhar forecasting that "the time will come, and it is not far off, when full-rigged ships will be seen sailing eastward and westward by Muirtown and Tomnahurich."

The Caledonian Canal was constructed by Telford after many engineers, including James Watt, had investigated the problem. There were many difficulties to overcome in this enterprise, amongst which was the difference of level of Loch Eil and Loch Lochy, of some 90 ft. This problem was disposed of by the building of the well-known flight of eight locks, named by Telford "Neptune's Staircase," at Banavie. The cost of construction of the canal was much in excess of the amount at first thought to be necessary, but that was not surprising when the difficulties the engineer met with are contemplated, and when one considers that even many modern canals have not been free from similar difficulties in regard to exact or covering estimates. With the development of trade and the use of boats of great tonnage, the limited depth of the water in the cuttings through the Great Glen, only amounting to 17 ft., and thus 3 ft. less than was originally intended by Telford, gave it a continuously reducing commercial value.

Another waterway, the Forth and Clyde Canal, was cut through what has become one of the greatest industrial districts of Scotland, but it also is only suitable for use by small craft.

The present state of unemployment has led to a revival of the interest in the construction of a deep-water canal suitable for the navigation of large ocean going liners between the east and west of Scotland. The hope of those who are advocating the claims of this scheme is that, apart from all other considerations, work can be found immediately for many thousands of men. Even were all the problems involved in the proposals already solved, the route agreed upon, and the details worked out, some time must, of course, elapse before the requisite plant would be available for use by the men, but its construction would at a very early date provide employment for a limited number of those who are at present walking the streets.

There are two distinct questions involved in the present suggestions. The first is the old one of the value of such an enterprise to the whole community, from the standpoints of commerce, and the national one of making a Navy, now of limited size, available for service in either the North Sea or the Atlantic Ocean in the shortest possible time. The second, that of providing employment at present, although it is entirely dependent on the decisions arrived at after the discussion on the first purpose, is considered to be the more important by the writers of letters to the daily press. Once it is demonstrated that such a venture is likely to prove an economic success, and after the value to the naval forces has been fully considered in order that the amount of any possible Government assistance may be gauged, and the route definitely decided upon, it will be time to consider the effect upon employment. At present, although various schemes and estimates have from time to time been put before the country, there is little hope of an immediate agreement on the question of route. The large business interests of Glasgow, the preferable route for use by the Navy, the possibility of industrial developments in new districts, are all factors in this determination, and there is at present no hope of any single scheme being acceptable to all the parties concerned.

It is advisable to consider the broad question of the necessity for the canal first of all before the effect on employment is to be looked at. Because Germany is developing her canal system and extending its sphere is surely not to be taken as evidence that a Mid-Scotland Canal is required. The proposal must be considered entirely on its merits, no matter what any other race or people may do in their own lands to meet the conditions prevailing there. The construction of the Manchester Ship Canal was a pure business transaction of providing a means of keeping down the heavy charges on cotton and other goods in their transport from the coast. With ships going right up to Manchester, the reduction of charges for handling in transferring goods to railway wagons, and the savings of railway freights, was apparent to all, and the capital was sunk in the venture to obtain that saving. When the advantage was obtainable, Manchester profited by an enormous accession of works in the neighbourhood of the docks. It cannot be said that similar conditions hold in regard to the Mid-Scotland Canal proposition. The construction of such a channel would, however, provide a shorter route between the east and west coasts (see map, Fig. 1) and remove the necessity for the hazardous journey in the heavy seas off the north of Scotland, which have no equal off any of the other coasts of the British Isles.

The estimate of the value of the total gain likely to be obtained is somewhat difficult, quite apart from the possible increase in the number of industrial works of all types which may spring up along the route.

Fig. 1.

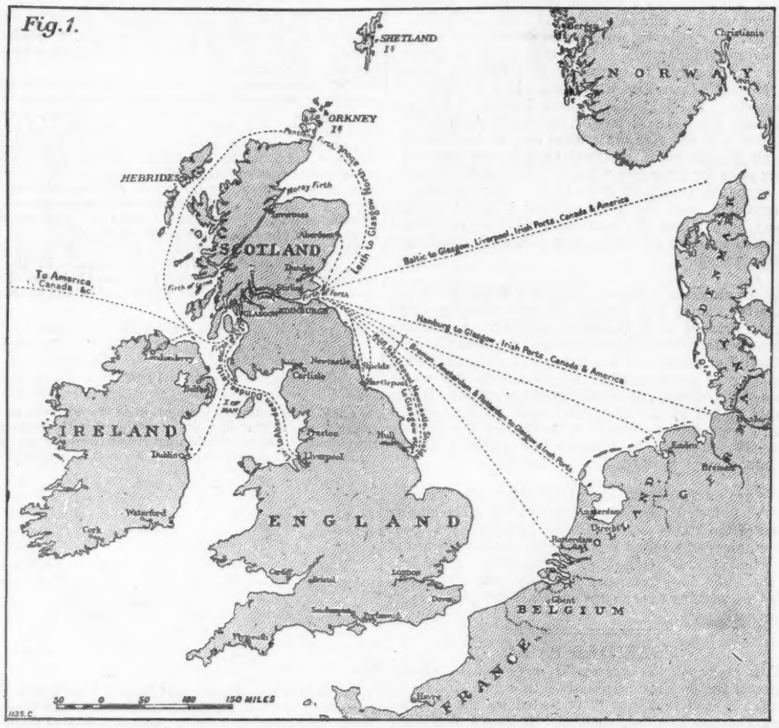
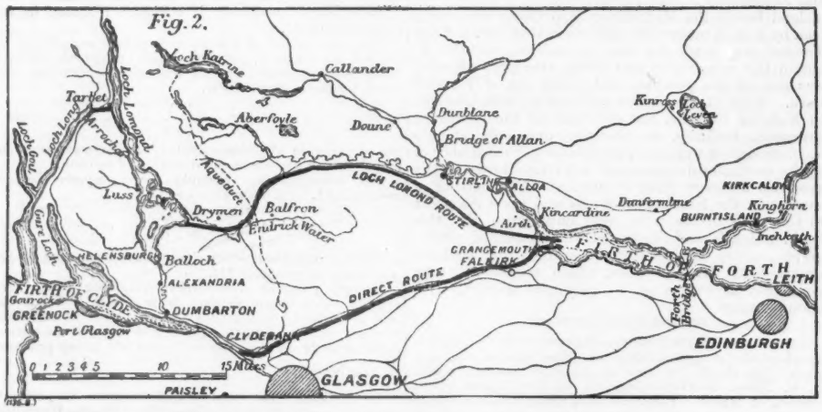


Fig. 2.



There are two main schemes whose relative merits have been discussed over and over again, that known as the Direct Route which would pass through the large industrial areas adjoining the present Forth and Clyde Canal and the other further north, making use of Loch Lomond as a part of the proposal. Each of these two suggestions, the routes of which are shown in Fig. 2, have devotees of a most whole-hearted character. The Direct Route would undoubtedly serve an area which is well provided with industrial works already, but would pass through some very congested districts. The other scheme is not so new a proposal as many of its advocates seem to think, for a similar suggestion involving the use of Loch Lomond, but in connection with a shallow canal, was examined by Smeaton, who decided in favour of the present Forth and Clyde Canal route. Conditions have changed since Smeaton's time and the problem is a different one, in that the depth must be at least twice that which he thought was all that was necessary. Land is costly in areas already developed and the Loch Lomond route offers a considerable advantage over the Direct Route in this respect. With such differences as are found in the views of the advocates of the Mid-Scotland Canal scheme there is, unfortunately, little or no hope of its being of any great service in reducing unemployment in the immediate future.

Schemes for the deepening and improvement of the Caledonian Canal have been put forward at various times, but the consideration of its value as a possible rival of the other suggestions seems to receive very little consideration nowadays.

A complete investigation of the problem from all points of view might serve to show the relative merits of the alternative proposals, but an acceptable compromise is difficult to obtain on the question of route.

PERSONAL.—Mr. Reginald Wilson states that he has resigned his position as Director of Aircraft Supplies at the Air Ministry as from December 31, and proposes to continue his practice as a consulting engineer, and has taken offices at Central House, Kingsway.—Messrs. A. Ransome and Co., Limited, Newark-on-Trent, ask us to draw the attention of our readers to the fact that they have not discontinued making several types of wood-working machines, and that they are still building a full range of machines for all wood-working purposes. They ask us to mention this since they keep hearing from different sources that they are only now making the heavier sawmill machinery.

THE KEGRESSE-HINSTIN CARS FOR THE SAHARA EXPEDITION.

THE public is following closely the attempt being made to cross the Sahara desert from Touggourt, south-east of Algiers, to Timbuctoo on the River Niger. The Citroën motor cars used for this unique performance are of the Kegresse-Hinstin type, of which we gave an illustrated description in former issues (see ENGINEERING, vol. cxi, page 234, and vol. cxiii, page 707) when we pointed out their suitability for service on the snow and for hauling heavy train loads in works' yards.

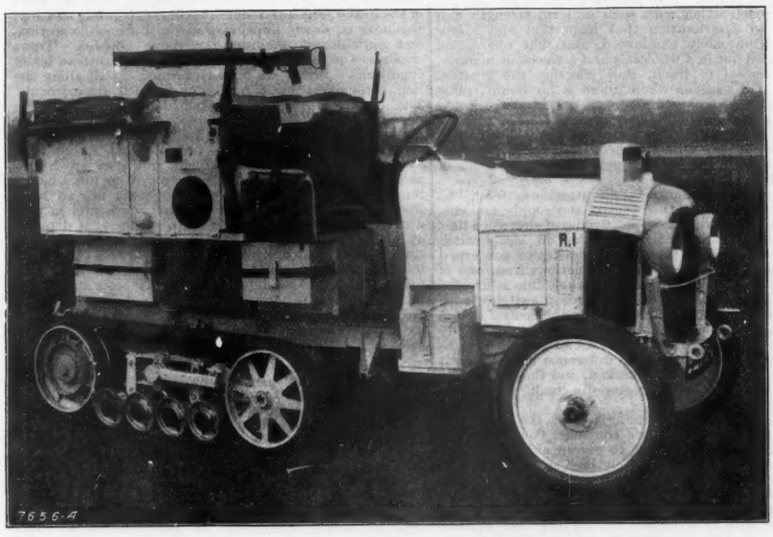


FIG. 1.

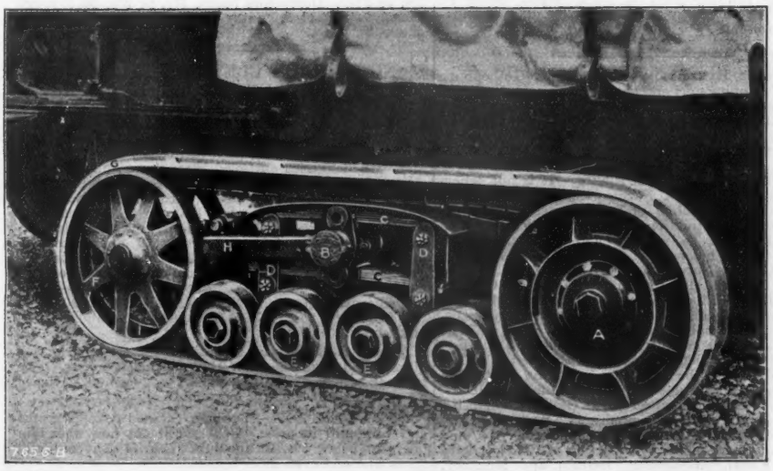


FIG. 2.

The further suitability of these cars for service on deep sand was ascertained by preliminary tests made in various sandy districts in France, notably in the region of Arcachon, south of Bordeaux. Following these, M. Citroën decided to send representative cars of this type to Algeria with a view to have them tested under actual conditions. The tests took place in the early months of 1922, when the cars travelled between different military posts and as far as In Salah, covering a total distance of about 20,000 km. (about 12,400 miles), on most difficult ground. These tests which were completed in March, 1922, took place in a season of very great heat and they led M. Citroën to take steps to attempt the journey through the desert, following the route marked on the map, Fig. 3. In order to ensure the necessary supplies, a first series of three cars was sent to Timbuctoo, *via* Dakar. From Timbuctoo, as a base, these cars carried petrol and stores to the military station at Kidal and, if possible, were to proceed as far as the Well of Tin-Zaouaten, situated at the limit of the Saharian oases and at the limit of the Niger territories. A second series of supply cars, having Touggourt as their base, have provisioned the Ouargla, Inifel and In Salah stations with petrol. The expedition proper, which is to cross the desert from Touggourt to Timbuctoo, is carried in four cars which left the first of these places in December, and at the time of writing had arrived safely in the vicinity of the Hoggar mountains. We illustrate one of these cars in Fig. 1.

In the first of our two articles above referred to, we gave a detailed description of the Kegresse driving mechanism on the occasion of the tests in snow on Mont Revard, in France, in February, 1921. We illustrate this in the view, Fig. 2. The gear takes the place of the driving wheels of an ordinary car. A pulley A is keyed at each end of the rear axle instead of the usual driving wheels, and the axle is not connected to the chassis by springs, as is usual in the ordinary type of car, but is allowed upward and downward play with reference to the chassis. The weight is carried on a special axle marked B in Fig. 2. Rocking levers C pivoted at their centre are provided at the ends of the axle B, the ends of the levers being connected by the flange plates D; the device further consists of the four intermediate pairs of wheels of small diameter E, over which the load is uniformly distributed. The pulley F acts as a support and guide for the endless belt G. The pulley F is connected to the vehicle by the levers H also joined on the axle B. When the car runs over projections on the ground the pulley F rises, the endless belt and gear are inclined to the rear and the small wheels continue to revolve easily. In order to ensure that the belt shall not come off, the pulleys A are twin-pulleys, a projection on the inside of the belt passing between the two. The twin-pulleys have a boss designed so that the halves can be brought closer together, in proportion to the resistance encountered in running, when the internal projection on the belt is firmly gripped at the pulley rims. The tension of the belt can be regulated by a hand-crank.

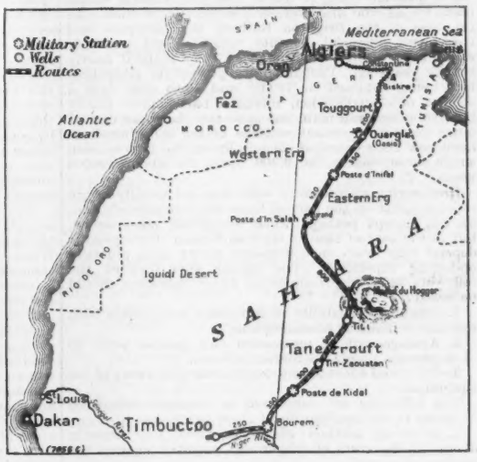


FIG. 3.

The chassis and motor are those of the well-known 10-h.p. Citroën car. The electric starting device only has been done away with as being unnecessary in the particular circumstances. The tests made on the spot, in the commencement of 1922, showed that the sand had no effect whatever upon the motors; analyses of the oil in the casings and a minute inspection of the motor component parts revealed no appreciable wear. Two of the supply cars sent to Timbuctoo and several of those which had their base at Touggourt are propelled by motors which had already run several thousand miles in the desert tests. No modifications have been made to the radiators and these are quite sufficient to cool the water notwithstanding the high temperatures encountered. The change-speed gear allows of six different speeds.

The supply cars have a seat in front for the driver and guide; they carried on a platform at the back of the seat iron casks, each containing 200 litres (44 gallons) of petrol. Two of these cars each carried two such casks, the two others having spare parts, food, ammunition, stores, &c. A car similar to that used for the expedition proper acted as escort to the supply cars, which started from the Touggourt base. The four cars carrying the expedition itself are all of the same build, having a seat in front arranged for three passengers. They each carry two petrol cases, 150 litres (33 gallons) in capacity each. On the cars is fitted an aluminium chest containing food, ammunition, tools, spare parts, drugs, &c. One of the cars is specially fitted for the taking of cinematograph views. Two water tanks containing 60 litres (13 gallons) are carried for use in the Tanesrouft, the region of thirst. Two of the four cars are fitted with a quick-firing gun. A tent is provided over each car body. M. Citroën and the other members forming the expedition are to be greatly congratulated for their enterprise.

A railway track to connect the French possessions in West Africa with Algiers has been planned repeatedly for the last forty or fifty years, but the scheme had to be abandoned owing to the difficulties of various kinds in the way. The Kegresse-Hinstin cars would greatly facilitate the work if this were put in hand. In the interim, they will constitute a valuable means of communication between outlying stations in those districts which hitherto have been practically cut off from the outside world.

CHANGE OF TITLE OF THE CONCRETE INSTITUTE.—Pursuant to an Order of Court made by Mr. Justice Eve on November 28, 1922, and confirmed by the Board of Trade, the title of The Concrete Institute has been altered to "The Institution of Structural Engineers." The address continues for the moment to be Denison House, Vauxhall Bridge-road, Westminster; but we learn that there is a prospect that in the near future the Institution will acquire premises of its own.

TWELVE YEARS' OPERATION OF ELECTRIC TRACTION ON THE LONDON, BRIGHTON AND SOUTH COAST RAILWAY.*

By HENRY WALTER HUNTINGFORD RICHARDS.

RAPID development of electric traction has been prevented by the European war, and, since its termination, by various other factors. This period of comparative inaction, however, has, perhaps, permitted experience in practical operation to be gained, sometimes with unexpectedly heavy traffic under conditions of reduced facilities. Further, the detailed investigation carried out by the Ministry of Transport resulted in the whole question being reviewed from the broadest standpoint by all who are interested in electric traction. In the case of the Brighton Railway the transport and consequent financial benefits which would probably result from electric traction were fully realised nearly twenty years ago, Parliamentary powers for electrification being obtained in 1903; and since that date a scheme of electrification, intended to comprise finally both suburban and main line operation, has been carried out. Certain important sections of the suburban lines have now been operated electrically on the high-tension single-phase system, at 6,700 volts, for about twelve years.

Engineering maintenance work does not usually excite much interest on the part of those not immediately concerned, except perhaps when something goes wrong, but in the case of electric traction further developments depend very much on conclusions drawn from practical operating experience. The author puts forward the following as main principles on which operation should be based:—

1. Maximum reliability of equipment compatible with reasonable financial considerations.
2. Arrangement of renovation and general work so as to prevent undue fluctuation of costs.
3. Continual effort to improve the life or working of the equipment.

The following are submitted as measures calculated to assist in the application of these principles:—

1. A group method of organisation for correctly allocating the costs of labour and material against the section concerned.
2. A clear division of all work under the two main headings of "Running-Maintenance" and "Repairs."
3. Preparation of graphic records and statistics of all results of practical operation and their circulation among the staff concerned.

The paper deals with the operation of electric traction on the Brighton Railway on these lines.

Rolling Stock—Electrical Equipment.—The efficiency of the current-collector gear is of fundamental importance, a difficult matter when the contact-wire varies in height from 13 ft. 9 in. to 20 ft. and has occasional steep gradients. The original bow-gear is running to-day, with only slight modifications, on every motor coach. The operating springs are set to standard lengths at coach overhauls so as to maintain a pressure of 12 lb. on the bow-strip at a trolley-wire height of 16 ft.

As usual for motor-coach equipments, the control is of the multiple-unit type. There are three principal train circuits, namely, high-tension main circuit at 6,700 volts, low-tension power circuit at 450 volts to 750 volts, and low-tension control circuit at 300 volts. It is found that a new motor-man can obtain a working knowledge of the control system in two to three weeks. The presence of the high-tension chamber in the guards' compartment has caused no trouble. The motors in use to-day are of the Winter-Eichberg single-phase compensated repulsion type, designed about fifteen years ago. Most of the motor troubles have been due to weakness in the mechanical design, and improvements have resulted in train defects being reduced by about 75 per cent. Split gears have been used hitherto with varying results, but gear wheel and pinion lives of 250,000 miles have frequently been obtained. Solid gear wheels of present-day manufacture should enable lives up to, or perhaps exceeding, 500,000 miles to be expected.

The transformers have so far been very satisfactory and reliable, only five defects having occurred among 71 transformers of the 310-k.v.a. type, many of which have now reached 500,000 miles. After about ten years' service the sheet insulation between the high-tension and the low-tension coils was renewed, and it is hoped that a considerable further life will accrue before further attention is required.

Rolling-Stock — Mechanical Equipment.—In motor-coach bogies every effort should be made to keep all clearances down to the minimum practical limit of wear. For this purpose axle-box horn cheeks have been fitted with U-shaped gun-metal liners, and similar attention has been given to all other points of wear, on bolsters, transoms, &c. Good braking is of the utmost importance. The Westinghouse automatic air brake, combined with clasp brakes and an automatic slack-adjuster, enable an average deceleration of not less than 3 ft. per second per second to be maintained, and the brakes to be released within about 3 seconds. Drivers' brake valves are cleaned and greased in position once in three months, and triple valves once in six months.

The original decision to use "side-door compartment stock" has been completely justified by the operating results obtained. Trains can be emptied and filled at terminal stations in about the same time as the motor-man takes to walk from one end to the other. All the original slam locks of the safety-catch type, with internal operation, are still in use. The voltage provided for train lighting is 300 volts, and four lamps are placed in series on each circuit. There are four 21-watt lamps in each compartment, but on different circuits.

Repair Shops.—Repair-shop and car-shed facilities are limited, and it is important, therefore, that both general overhaul and inspection work should be kept strictly within the mileage limits fixed for each job. Further, detail inspection is done by day, once in three weeks, and night work is confined to indispensable electrical and mechanical examination. General overhaul of motor-coaches takes place at 60,000 miles, equivalent to eighteen months' running, and of trailer coaches at 120,000 miles.

Electric Track Equipment.—In order that the current collection by the bows may be good, considerable attention has been given to rendering the trolley wire absolutely flexible at all points. It is also desirable to provide the overhead construction with such uniform strength and resistance to deterioration that inspection and minor repairs can be safely eliminated, and that renovation can be carried out in a wholesale and convenient manner, like the renewal of track, thus effecting the greatest economy. On sections where there is no steam traffic the renewal of catenary and dropper wires necessitated by corrosion is only about 10 per cent. of that on sections where a heavy steam traffic is still running. The rate of wear of the trolley wire has been found to be almost directly proportional at any point to the amount of current collected there.

Two central distributing switch cabins, with one attendant in each, together control the supply and distribution of energy to the whole 70 miles of electrified line. When necessary, the trolley switches in local switch cabins are operated by the staff at the station concerned in accordance with telephoned instructions from one of the central switch cabins. As the whole line is divided into five group sections, for which group switches with instantaneous tripping are provided in the central switch cabins, switch-gear operation and maintenance is chiefly confined to these group switches. An advantage of high-tension distribution is that the difference between fault and normal currents is very marked, and the consequent automatic location of faults materially conduces to safety and reliability of operation.

Train-Driving.—The characteristic of the motors is such that the use of only five controller steps increases the voltage in such a way as to obtain almost uniform acceleration until a comparatively high speed is reached. Motor-men change step by observing the value of the current indicated by an ammeter, and the points for shutting off current are marked by "coasting boards" fixed at the side of the line. During 1921 the average energy consumption was 75·8 watt-hours per ton-mile, the train service being 5,959,737 coach miles, with a distance between train stops of 1·14 mile, an average running-speed of 24·36 m.p.h., and a schedule speed of 22·11 m.p.h. including stops. A series of test runs was recently taken over a range of 0·4 mile to 9 miles between stops, from which it appeared that for the latter distance an average running-speed of 33·1 m.p.h. could be obtained with an energy consumption of only 40 watt-hours per ton-mile.

* Abstract of a paper to be read before the Institution of Civil Engineers on Tuesday, January 9, 1923.

GOTHENBURG EXHIBITION.—The City of Gothenburg—the chief shipping port and export harbour in Sweden—will celebrate the tercentenary of its foundation with a Jubilee Exhibition, to be held from May 8 to September 30, 1923. The address of the Exhibition Bureau is Utställningsbyrån, Gothenburg 5.

THE LATE PROFESSOR NARUTOWICZ.—It is not generally known that Gabriel Narutowicz, who was lately President of the Republic of Poland, was an engineer of considerable distinction highly esteemed both in Switzerland, where he worked and taught, and in other countries, before he returned to his native country. Gabriel Narutowicz was born at Telsche, in Lithuania, in 1865, and was educated at the German classical school in Libau and at the University of Petrograd, where mathematics were his chief study. Dissatisfied with the political conditions he went in 1886 to Switzerland and completed his engineering studies, interrupted by prolonged illness, at the Federal High School of Zürich in the year 1891. Having worked on railways he became connected with the firm of Messrs. Kursteiner, consulting engineers, of St. Gallen. Remaining with them for thirteen years, finally as a partner, he devoted himself mainly to hydraulic engineering. He had an important share in the construction of the electricity works of Kubel, Andelsbuch, Refrain and Monthey, and when in 1908 the professorship of hydraulic engineering at the Zürich Federal High School fell vacant, he was offered this post, which he filled to the full satisfaction of the authorities and of his students. His academical duties enabled him to continue his activity as a consulting engineer; his name became chiefly known in connection with the repair of the electricity works at Wangen and with the power plants at Mühleberg on the Aare; at Montjovet in the Aosta Valley, and at Buitreras in Spain. The work at Mühleberg was much impeded by the war and was considered to have been particularly well carried out. A member of several Swiss technical commissions, he was also elected a member of the International Commission for the Regularisation of the Rhine. When matters quieted down in Poland, he left Switzerland early in 1920, where he had lost his wife, and accepted the arduous post of Minister of Public Works in Poland. A man of rare energy, he achieved great success as reconstructor of streets, houses and bridges. His country then sent him to the Genova Conference as second Polish delegate, and made him subsequently Minister of Foreign Affairs. On December 9 he was elected President of the Republic for the period of seven years; seven days later he fell a victim to political fanaticism, on December 16.

NOTES FROM SOUTH YORKSHIRE.

SHEFFIELD, Wednesday.

Iron and Steel.—The New Year opens with considerable promise, improved order books and an abundance of inquiries are reflected by a distinctly more cheerful tone in manufacturing circles. The Master Cutler, Mr. R. W. Matthews, in a special interview, expressed optimism, and forecasted that the next few months would witness a substantial improvement in the steel and engineering industries, especially among manufacturers of railway material and engineers' tools. Some nice orders have already been placed with Sheffield and allied firms by home and overseas railways, and more are confidently expected at an early date. The revival in shipbuilding materials is at present slight, but judging from the state of the heavy forges and foundries, it is expanding steadily. Business is slowly improving in the automobile section, and agricultural engineers are more hopeful. Trade organisers are anxious to avoid a sudden return to boom conditions. Prices are already firming up all along the line throughout basic and semi-finished departments. The danger foreseen by responsible students of the position is that a too-rapid recovery would cause an undesirable inflation of values and check the flow of new business. Basic steel works are not less active than towards the close of the old year, but they are by no means the only departments that are turning out a heavy tonnage. Some of the hire rolling-mills are so busy that within the last three weeks they have broken pre-war records of output. Steel scrap is in urgent demand at higher rates, more furnaces having been put into commission. A steadily expanding business is being done in drills, hacksaws and fishbolts. Special attention is being paid to the manufacture of cheap tools and implements for certain parts of the Colonies. Manufacturers are protecting their reputation for high-grade products by using exclusive trade marks for the lower quality articles.

South Yorkshire Coal Trade.—With the market only just recovering from the holiday stoppage, at the pits business is restricted, but stocks are light and collieries occupy a fairly strong position with regard to the immediate future. Industrial fuel will come more into the picture towards the end of the week. Meantime heavy tonnages of best steams are going inland on contract account, and there is a fair demand for shipment. House-coal orders have accumulated at depots over the holidays, but merchants have adequate reserves at their command to meet requirements. Cobbles and nuts are firmly maintained at recent advances. By-product plants are taking an increased tonnage of slacks. Furnace coke continues strong. Quotations:—Best branch handpicked, 32*s.* 6*d.* to 34*s.* 6*d.*; Barnsley best Silkstone, 28*s.* to 30*s.*; Derbyshire best brights, 24*s.* to 26*s.*; Derbyshire best house, 21*s.* 6*d.* to 22*s.* 6*d.*; Derbyshire best large nuts, 19*s.* 6*d.* to 22*s.* 6*d.*; Derbyshire best small nuts, 15*s.* to 16*s.* 6*d.*; Yorkshire hards, 20*s.* to 21*s.*; Derbyshire hards, 19*s.* to 20*s.* 6*d.*; rough slacks, 9*s.* to 11*s.*; nutty slacks, 7*s.* 9*d.* to 9*s.* 9*d.*; smalls, 3*s.* to 5*s.*

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

The Cleveland Iron Trade.—Little new can be reported concerning Cleveland pig-iron. As is usual at this season of the year business has been practically at a standstill, and with deliveries curtailed through consuming works closing for the holiday week, producers have been able to accumulate a little stock—a circumstance welcomed by some firms who have had little or no iron on hand for some time past. The opinion now prevails that successful Continental competition to any extent is no longer to be feared, but Midland iron is still underselling Cleveland pig-iron in some markets. The f.o.t. makers' works, and f.o.b. quotations stand:—No. 1 and siliceous sort, 95*s.*; No. 3 G.M.B., 90*s.* to 90*s.* 6*d.*; No. 4 foundry, 85*s.*; No. 4 forge, 82*s.* 6*d.*; and mottled and white, 80*s.*

Hematite.—East Coast hematite makers are fairly well placed, and take the view that output promises to be fully absorbed. Nos. 1, 2 and 3 run from 92*s.* 6*d.* to 93*s.*; and No. 1 is put at a premium of 6*d.*

Blast-Furnace Coke.—Durham furnace coke is scarce and very stiff in price. Sellers will not now entertain offers at below 30*s.* for medium qualities delivered, and up to 31*s.* and even more is asked.

Foreign Ore.—Dealers in foreign ore admit that sales are still very slow, but are inclined to take a more hopeful view of the outlook. Best rubio is 22*s.* to 22*s.* 6*d.* c.i.f. Tees.

Manufactured Iron and Steel.—The situation in finished iron and steel is much improved. Most manufacturers have now made good contracts, and expect to book further substantial orders. Among the principal market quotations are:—Common iron bars, 10*l.* 10*s.*; iron rivets, 10*l.* 7*s.* 6*d.*; packing (parallel), 8*l.*; packing (tapered), 11*l.*; steel billets (soft), 8*l.*; steel billets (medium), 8*l.* 10*s.*; steel billets (hard), 8*l.* 15*s.*; steel boiler plates, 12*l.* 10*s.*; steel ship, bridge and tank plates, 9*l.* to 9*l.* 5*s.*; steel angles, 8*l.* 15*s.*; steel rivets, 11*l.* 7*s.* 6*d.*; steel joists, 9*l.* 10*s.*; tees, 10*l.*; heavy sections of steel rails, 9*l.*; fish plates, 13*l.* to 14*l.*; black sheets, 11*l.* 10*s.*, and galvanised corrugated sheets (No 24. gauge, in bundles), 17*l.*

Shipments of Iron and Steel.—Shipments of iron and steel from the port of Middlesbrough last month reached 84,101 tons, to which must be added 5,229 tons of pig-iron loaded at Skiningrove, which makes the total despatched from the Tees district 89,329 tons. Of the Middlesbrough clearances, 39,188 tons were pig-iron,

5,701 tons going coastwise and 33,487 tons going to foreign ports; 1,846 tons were manufactured iron, 935 tons going coastwise and 911 tons foreign; and 43,067 tons were steel, 7,381 tons going coastwise and 35,685 tons foreign. The United States was the principal purchaser of pig-iron, importing 22,450 tons; Wales being second with 3,050 tons; whilst Belgium took 2,850 tons; France, 1,912 tons; Scotland, 1,675 tons; Germany, 1,505 tons; and Sweden, 1,314 tons. India was the heaviest recipient of both manufactured iron and steel, taking 338 tons of the former, and 6,715 tons of the latter. Other chief customers for steel were:—Portugal, 5,300 tons; West Australia, 4,572 tons; New South Wales, 3,723 tons; Victoria, 3,110 tons; and New Zealand, 2,640 tons.

NOTES FROM THE NORTH.

GLASGOW, Wednesday.

Scottish Steel Trade.—With the finish of the year 1922 there has been placed behind us one of those poor years which the Scottish steel-maker is not sorry to see relegated to the past. Certainly it has been a trifle better than its predecessor, but it will rank a long way behind 1920, when the output was on a very large scale. During the year there were one or two brighter periods, but at no time was there experienced any great pressure for deliveries of almost any class of material. With the shipbuilding trade tailing off as it did, and few new contracts being booked to take the places of those vessels launched, the demand for ship plates was at times a negligible quantity. The price was not always satisfactory either from the producers' or the consumers' point of view. At the beginning of the year the price was 10*l.* 10*s.* per ton, but it declined on various dates until it reached 8*l.* 15*s.*, at which figure the year closed. In the case of angles the position was much the same and no great demand was experienced. Prices also showed a fall and the price of 10*l.* a year ago is called 8*l.* 7*s.* 6*d.* per ton to-day. Boiler plates fell from 14*l.* per ton last January to 12*l.* per ton as from November. One item worth recording here was the "freeing" which took place in August when the old existing home-selling agreement went by the board, but boiler plates were made the exception. The makers of black steel sheets have not had a very brilliant year, and, except for one or two periods of fair shipping orders for the thinner gauges, trade on the whole has been poor. The prices for sheets, $\frac{3}{16}$ in. to $\frac{1}{4}$ in. thick, were 12*l.* 5*s.* per ton when the year opened, but reductions for the home market were made on three occasions and the year closed with the quotation at 10*l.* 10*s.* per ton. All over prices have declined and producers have still had to face their heavy on-cost charges and much of the business which was taken was only to keep plant running, with the result that there was practically no margin of profit, and in many cases an actual loss. Continental competition was very keen for a number of months, but poor deliveries caused many orders to be cancelled, which acted in favour of the home product.

In dealing with the prospects for the new year it can only be said that the outlook is quite promising. Much has been written in different quarters regarding the increase in trade which, we are assured, is about to take place. That state would be extremely welcome to all, but it will be some time yet before conditions are really better. Quite a number of new shipbuilding orders have been placed recently and much has been made of that, but hundreds more are required to give our many shipyards even a semblance of the activity we have been used to in past years. Costs of construction are about as low just now as can be expected, and there would seem to be a greater possibility of steel material advancing than falling in price. If our foreign trade increases as we expect it to do on account of the bareness of many of the markets abroad, the costs of production will be eased and prices keep steady.

Malleable-Iron Trade.—The high cost of production, coupled with a very poor demand for bar iron, has made the past year a very moderate one in the malleable-iron trade of Scotland. Makers have been faced with difficulties all the time, and so keen was the competition for any orders on offer that much business was accepted of an unprofitable nature. The workers have also had a very poor time because of so much unemployment, but the outlook is better now and there are prospects of more regular work for them this year. Over the year the home requirements were very small indeed, and not until the closing days was there any sign of improvement. The export side of the trade has not been at all satisfactory, but there again the prospects are better, and not only have Colonial buyers been forward recently with some good inquiries, but one or two quite respectable lines were picked up towards the end of the year. Prices eased off during the year and marked a fall of 2*l.* per ton, "crown" bars being 12*l.* 10*s.* per ton last January and 10*l.* 10*s.* per ton to-day, delivered Glasgow.

Scottish Pig-Iron Trade.—The year 1922 was one of many trials to the makers of pig-iron in Scotland, and ups and downs were numerous. In the early months of the year the home demand was almost *nil*. Export trade was also insignificant, with the result that the nine furnaces in blast were more than able to meet all requirements, with even some over to stock. In the spring came the engineering trade lock-out which lasted three months and which effectively took the bottom out of the small business doing. But before that dispute had ended labour troubles in America broke out, with the result that urgent inquiries for pig-iron were received on this side. The local makers were fortunate to secure a fair amount of the business offered, although at a very low price, and not only were accumulations of stocks cleared out in a hurry, but more furnaces were lighted, and by the autumn there were 30 in full blast. When the demand fell away towards the end of the year stocking had again to be indulged in. The prospects of the trade for this year are a bit uncertain, but it is believed we are round the corner now and that a steady improvement will take place. Prices have fluctuated during the year, and No. 1 foundry iron at its highest point was 5*l.* 12*s.* 6*d.* per ton and No. 3 was 5*l.* 7*s.* 6*d.* per ton. The lowest quotations were: No. 1, 4*l.* 15*s.*, and No. 3, 4*l.* 10*s.*, while to-day the prices are called 5*l.* per ton for No. 1, and 4*l.* 15*s.* per ton for No. 3, delivered makers' works. The story of Scottish hematite for the past year is very brief because of the very unsatisfactory demand for steel from shipbuilders. For a considerable period only one furnace was turning out hematite iron, but latterly the demand got better and several others were put into commission. The outlook is much brighter now and considerable more business is anticipated by the spring. To-day's price is 5*l.* 7*s.* 6*d.* per ton, delivered at the steel works, which is 7*s.* 6*d.* per ton under the highest price of the year, but 2*s.* 6*d.* per ton over the lowest.

Scottish Shipbuilding.—The Scottish shipbuilding industry of 1922 may be described as very disappointing indeed. There have been many factors against the trade, largely due to the backwash of the war, but it is generally thought that we are now past the worst and that our great industry will gradually get better as this year goes on. The output was not satisfactory, as the following figures show:—

	1922.		1921.	
	Vessels.	Tons.	Vessels.	Tons.
The Clyde	143	388,481	249	511,185
The Forth	22	22,430	26	37,485
The Tay	10	32,279	14	18,336
The Dee and Moray Firth	15	3,807	24	13,210
Total	190	446,997	313	580,216

Even when the figures of last year are compared as above with those of the preceding year, they do not show up too well. The Clyde output in particular is a long way below the record year, but the prospects at present are all tending towards a revival and, perhaps, a much better return will be possible a year hence.

NOTES FROM THE SOUTH-WEST.

CARDIFF, Wednesday.

The Coal Trade.—In November the surplus profits of the South Wales coal trade amounted to 216,987*l.*, but, as a surplus of 407,000*l.* is required to pay the minimum wage, the coalowners are again compelled to sacrifice 191,000*l.* of their profits. The wage payable according to the joint accountants' certificate is 16·09 per cent. above the 1915 standard, but the minimum is 28 per cent. above the standard, to which must also be added the subsistence wage fixed under the recent award of Lord Buxton. In the twelve months ended November the coalowners have been compelled to sacrifice no less than 3,057,000*l.* in the payment of the minimum wage, and the whole of this sum is irrecoverable. Compared with October the output showed an increase of 171,000 tons and the wages cost per ton fell 1*d.*, but this was offset by an increase of 1*d.* per ton in "other costs," owing to an advance in the price of materials, particularly pitwood. The revenue of the coal trade in November suffered from an appreciable decline in the prices of anthracite and steam small coals. Anthracite small was reduced from 26*s.* 4*d.* to 26*s.* 3*d.* and large from 49*s.* 5*d.* to 47*s.* 11*d.*, while steam smalls averaged 16*s.* 6*d.* compared with 16*s.* 11*d.* in October. The amount of wages paid in November was 2,443,502*l.*, compared with 1,678,000*l.* in the corresponding month of 1913, an increase of 765,000*l.* for producing the same quantity of coal. Exports of coal as cargo from South Wales last year amounted to 25,700,000 tons, compared with 11,800,000 tons in the 1921 strike year, 12,300,000 tons in 1920, and 29,875,000 tons in 1913. Thus exports last year were doubled as compared with the previous twelve months, but 4,000,000 tons less than in the pre-war year. The question of a third working shift for coal trimmers and tippers at the docks is still receiving the serious attention of the employers and workmen, and a joint conference has been arranged to deal with the matter. It is, however, expected that the whole question will be submitted to an inquiry under the Industrial Courts Act. The American demand for Welsh coal is again assuming large proportions. It is, however, impossible to estimate the business placed or in negotiation as the orders and inquiries have been placed among so many firms. At any rate it is known that, besides contracts for 50,000 tons and 100,000 tons, several vessels of from 5,000 tons to 7,000 tons have been fixed to load cargoes this month, while there are still several definite orders for tonnage in the market. Meanwhile, prices have developed irregularity by reason of tonnage having been delayed by the recent bad weather. For quick shipment, Admiralty large coals are obtainable at 27*s.* to 27*s.* 6*d.* and smalls at 17*s.* to 17*s.* 6*d.*, but for shipment ahead 6*d.* to 1*s.* more is firmly demanded.

Iron and Steel.—In view of the intervention of the Christmas holidays, shipments of iron and steel goods last week were reduced to 3,594 tons, compared with 24,059 tons in the previous week. Exports of black plates totalled 906 tons, against 1,290 tons; tin plates 953 tons, against 9,980 tons; galvanised sheets 128 tons, against 4,453 tons; and other iron and steel to 1,607 tons, against 8,336 tons. There is an improved demand for Welsh tin plates on both home and foreign account on prices firm on the basis of 20*s.* 3*d.* to 20*s.* 6*d.* per basis box.

NOTICES OF MEETINGS.

THE INSTITUTION OF LOCOMOTIVE ENGINEERS (LONDON): MANCHESTER CENTRE.—Friday, January 5, at 7 p.m., at the College of Technology, Sackville-street, Manchester. Paper by Mr. H. Kelway Bamber, M.V.O., on "South African Railways and Rolling-Stock."

THE INSTITUTION OF AERONAUTICAL ENGINEERS.—Friday, January 5, at 6.30 p.m., at the Engineers' Club, Coventry-street, W. Discussion on "Gliding" and "Gliders at Itford."

THE BRADFORD ENGINEERING SOCIETY.—Monday, January 8, at 7.30 p.m., in the Hall of the Bradford Technical College. Lecture by Mr. F. C. H. Lantsberry on "Steel Castings."

THE SURVEYORS' INSTITUTION.—Monday, January 8, at 8 p.m., in the Lecture Hall of the Institution, 12, Great George-street, S.W.1. Paper by Mr. F. W. Hunt, entitled "Zoning in the Control of Large Cities."

THE INSTITUTION OF ELECTRICAL ENGINEERS: SCOTTISH CENTRE.—Tuesday, January 9, at 7 p.m., at the North British Station Hotel, Edinburgh. Paper, "Domestic Load Building," by Mr. W. A. Gillott.

THE INSTITUTE OF INDUSTRIAL ADMINISTRATION.—Tuesday, January 9, at 8 p.m., at the London School of Economics, Houghton-street, Aldwych, W.C. 2. Lecture on "The Future of Payment by Results," by Mr. J. E. Powell.

THE INSTITUTION OF CIVIL ENGINEERS.—Tuesday, January 9, at 6 p.m., Ordinary Meeting. Paper to be submitted for discussion: "Twelve Years' Operation of Electric Traction on the London, Brighton and South Coast Railway," by Mr. Henry Walter Huntingford Richards.

THE INSTITUTE OF MARINE ENGINEERS.—Tuesday, January 9, at 6.30 p.m., at 85-88, The Minories, Tower Hill, E.1, "Gas Engines and Gas Producer Plants," by Hugh Campbell.

THE INSTITUTE OF METALS: BIRMINGHAM LOCAL SECTION.—Tuesday January 9, at 7 p.m., in the Chamber of Commerce, New-street. Paper on "X-Rays and Crystal Structure," by Mr. H. B. Keene, D.Sc.

THE INSTITUTE OF METALS: SCOTTISH LOCAL SECTION.—Tuesday, January 9, at 7.30 p.m., in the rooms of the Institution of Engineers and Shipbuilders in Scotland, 38, Elmbank-crescent, Glasgow. Paper on "The Heat Treatment of Some Industrial Non-Ferrous Alloys," by Professor F. C. Thompson, D.Met., B.Sc.

THE INSTITUTION OF AUTOMOBILE ENGINEERS.—Wednesday, January 10, at 7.45 p.m., at the Institution of Mechanical Engineers, Storey's Gate, St. James's Park, S.W. 1. Paper, "Railless Trolley Traction," by Mr. O. W. J. Taffs, B.Sc.

THE INSTITUTION OF ELECTRICAL ENGINEERS: WIRELESS SECTION.—Wednesday, January 10, at 6 p.m., in the Lecture Theatre of the Institution, Victoria Embankment, W.C. 1. "Design of Radio Towers and Masts: Wind Pressure Assumptions," by Mr. C. F. Elwell.

THE ROYAL SOCIETY OF ARTS.—Wednesday, January 10, at 3 p.m., at John-street, Adelphi, W.C. 2. Juvenile Lecture, "The Spectrum, its Colours, Lines and Invisible Parts, and Some of its Industrial Applications" (Lecture II), by Mr. Charles R. Darling, A.R.C.Sc., F.I.C.

THE INSTITUTE OF METALS: LONDON LOCAL SECTION.—Thursday, January 11, at 8 p.m., in the Rooms of the Institute of Marine Engineers, 85 to 88, The Minories, Tower Hill, E.1. Paper on "Some Aspects of Electrodeposition," by Mr. W. E. Hughes, B.A.

INSTITUTION OF MECHANICAL ENGINEERS.—Friday, January 12, at 7 p.m., Storey's Gate, St. James's Park, S.W.1. Informal meeting. Subject, "Technical Journals and their Use to the Engineering Profession." Discussion to be opened by Mr. A. P. Bale.

THE JUNIOR INSTITUTION OF ENGINEERS.—Friday, January 12, at 7.30 p.m., at 39, Victoria-street, S.W. 1. Paper, "Transient Phenomena Arising in Transformers from Switching Operations," by Mr. S. A. Stigant.

THE NORTH-EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS.—Friday, January 12 and 26, at Bolbec Hall, Newcastle-on-Tyne. "Review of Different Types of Marine Internal-Combustion Engines." Contributions by Sir W. G. Armstrong, Whitworth and Co., Limited; William Doxford and Sons, Limited; Hawthorn, Leslie and Co., Limited; Palmers Shipbuilding and Iron Company, Limited; Scott's Shipbuilding and Engineering Company, Limited; Swan, Hunter and Wigham Richardson, Limited; and Vickers, Limited.

THE LONDON IRON AND STEEL EXCHANGE.—The quarterly meeting will be held at the Metal Exchange Rooms, Whittington-avenue, E.C. 3, on Tuesday, the 9th inst., when Sir Philip Pilditch, M.P., will give an address on "Our Overseas Markets in South America, and particularly Brazil."

BRITISH EMPIRE EXHIBITION.—In view of the large demand for space—particularly for the engineering and electrical exhibits—at the British Empire Exhibition, it has been found necessary to recommend the extension of the Machinery Hall by the addition of 70,000 sq. ft. of space, in order to house the entire sea and land transport group of exhibits in the extension. The Machinery Hall, when extended, and the already extended Industrial Hall, which originally occupied a combined area of 800,000 sq. ft., will cover 889,415 sq. ft. The two halls face to each other, on either side of the Grand Avenue.

THE TWIN-SCREW GEARED TURBINE CUNARD STEAMER "SAMARIA."

CONSTRUCTED BY MESSRS. CAMMELL LAIRD AND CO., LIMITED, SHIPBUILDERS AND ENGINEERS, BIRKENHEAD.

(*For Description, see Page* 8.)

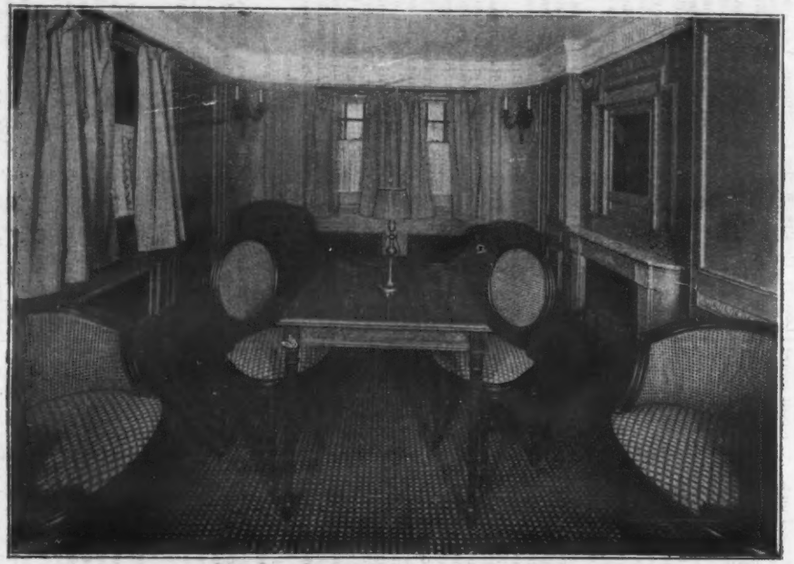


FIG. 21. SITTING-ROOM OF SPECIAL SUITE.

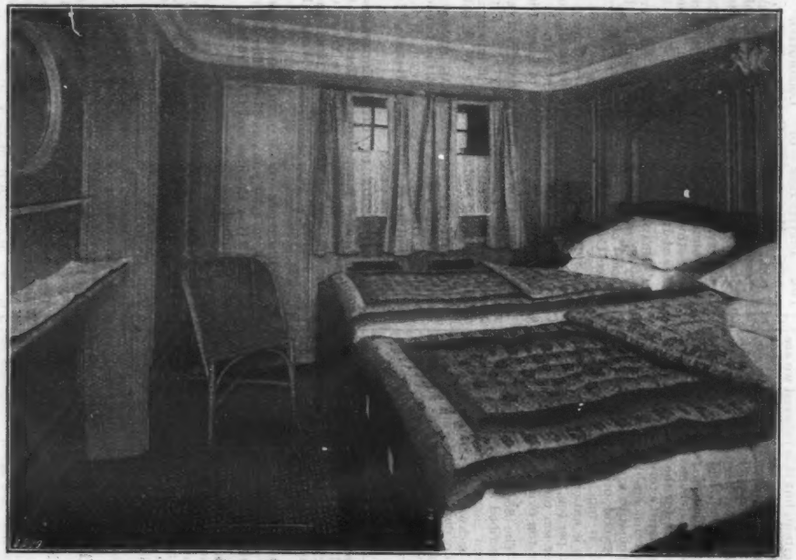


FIG. 22. BED-ROOM OF SPECIAL SUITE.

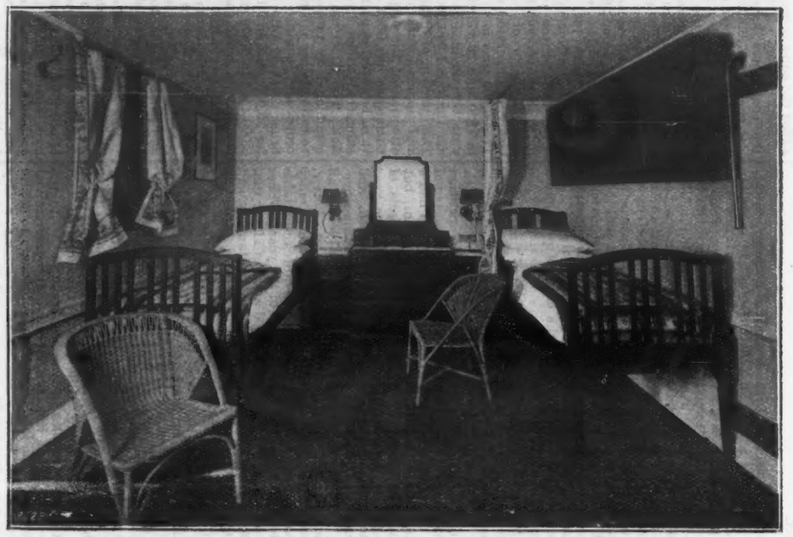


FIG. 23. FIRST-CLASS CABIN.

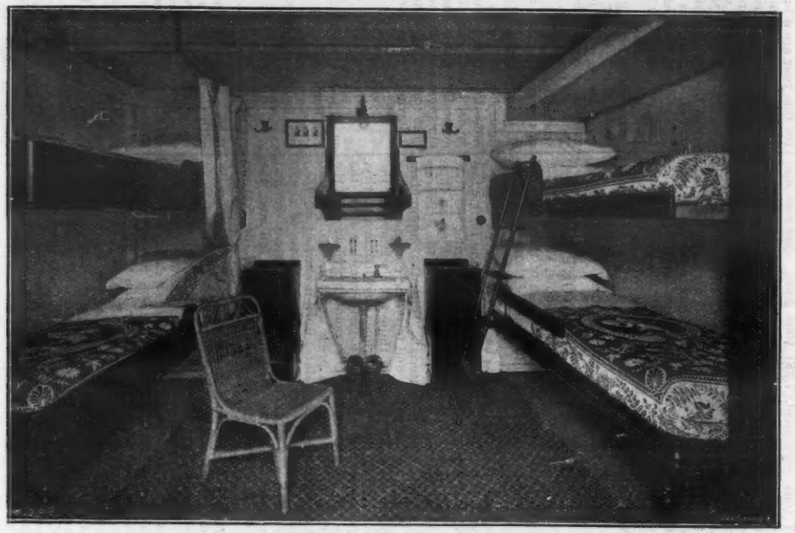


FIG. 24. FIRST-CLASS FOUR-BERTH CABIN.

Fig. 23. First-Class Cabin.

Fig. 24. First-Class Four-Berth Cabin.

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(*For Description, see Page* 8.)

Fig. 3. First-Class Lounge.

Fig. 4. Verandah Cafe.

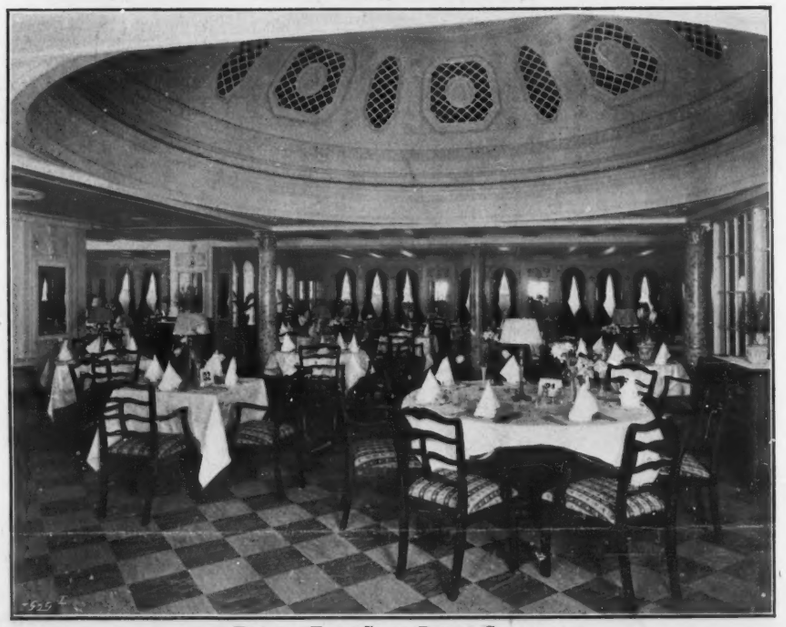

Fig. 5. First-Class Dining Saloon.

Fig. 6. First-Class Smoking Room.

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Fig. 7.

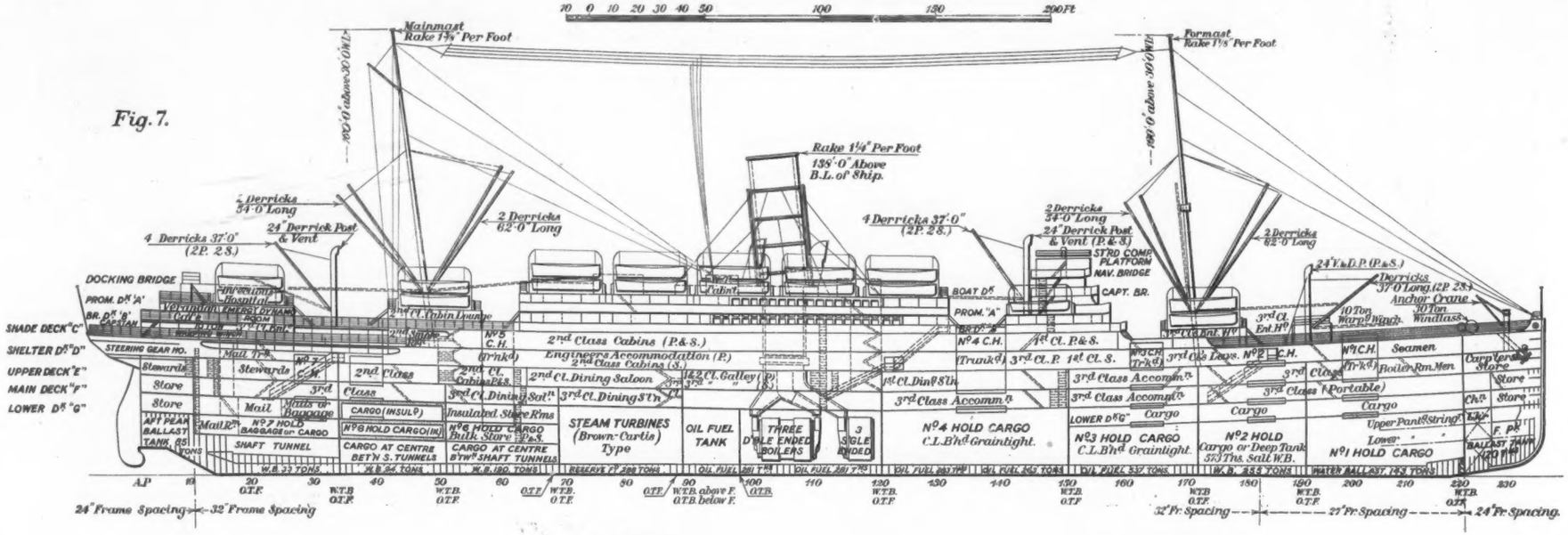

Fig. 8.

DOCK.g BR.GE

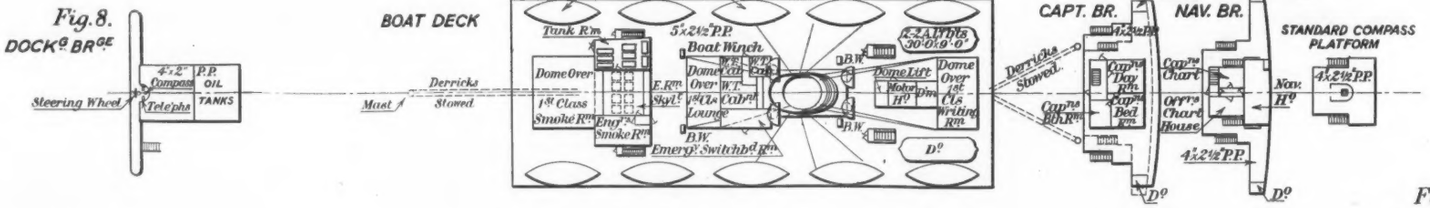

Fig. 9.

PROM. D.K "A"

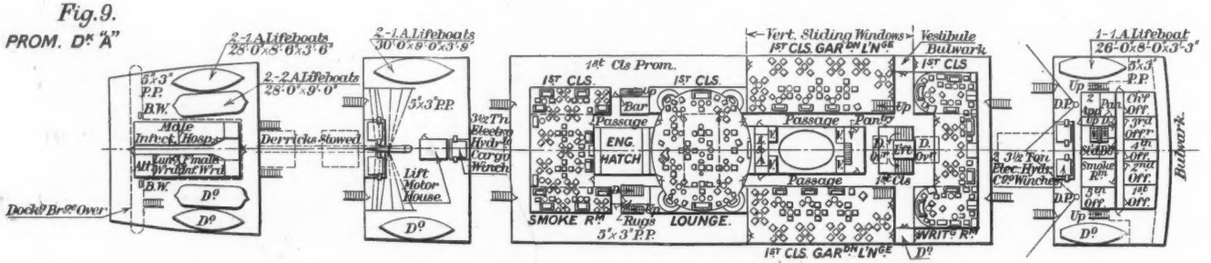

Fig. 10.

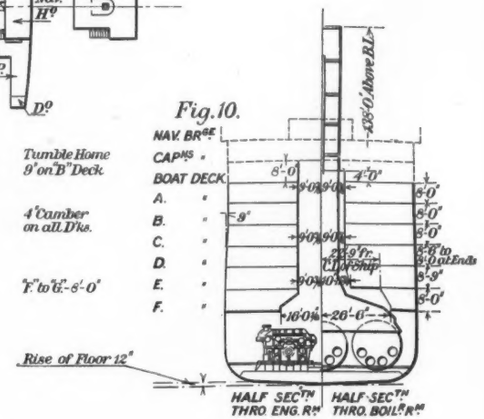

Fig. 11.

BRIDGE D.K "B"

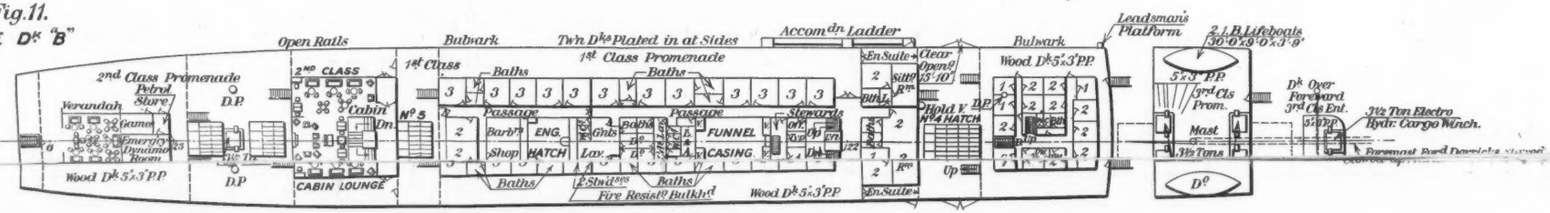

Fig. 12.

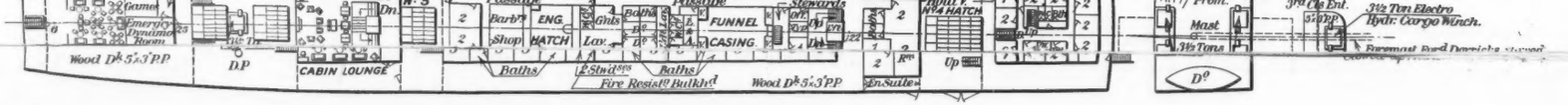

Fig. 12.
SHADE Dk "C"

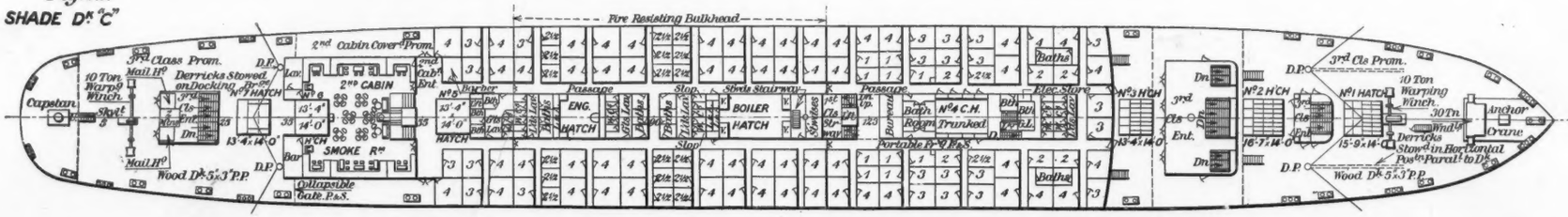

Fig. 13.
SHELTER Dk "D"

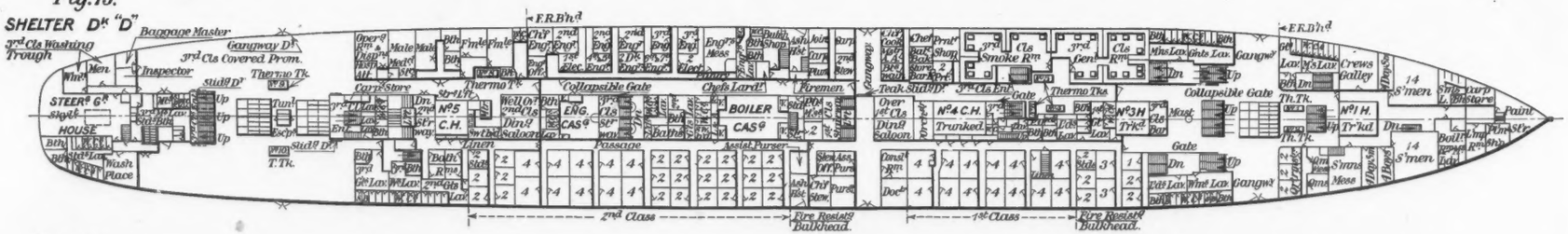

Fig. 14.
UPPER Dk "E"

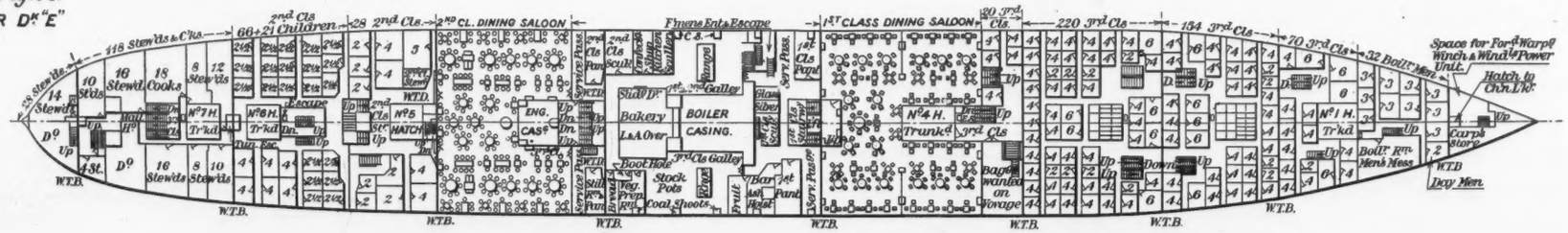

Fig. 15.
MAIN Dk "F"

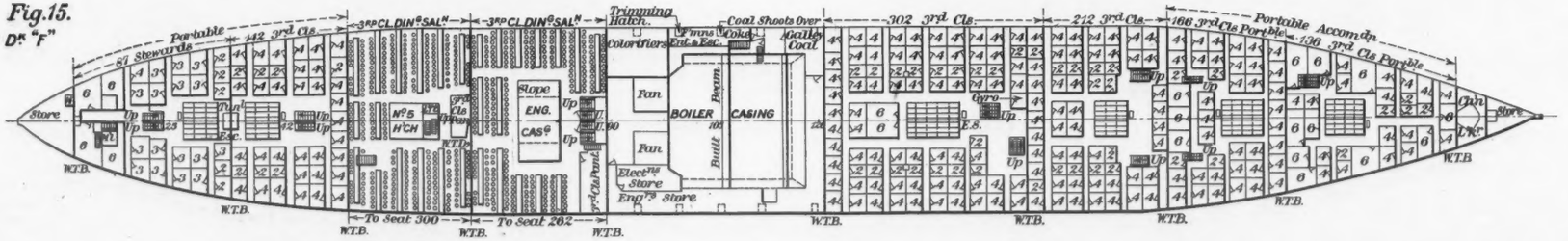

Fig. 16.
LOWER Dk "G"

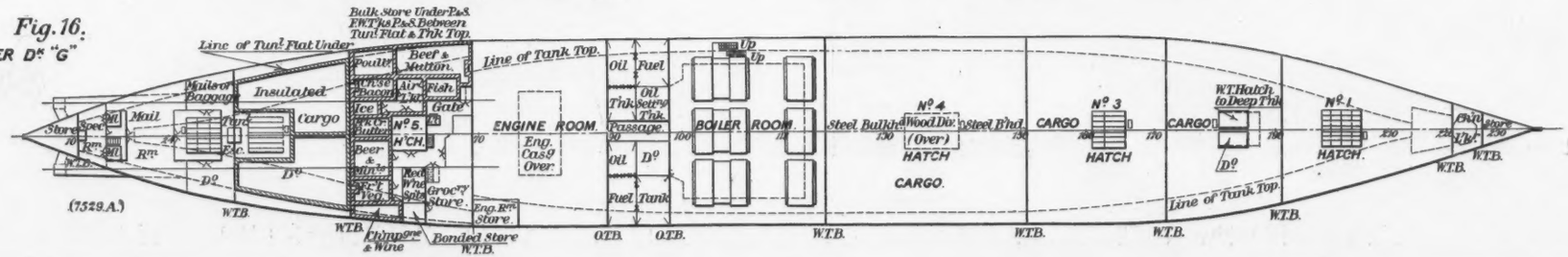

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FIG. 17. LIBRARY.

FIG. 18. SECOND-CLASS DINING SALOON.

FIG. 19. SECOND-CLASS LOUNGE.

FIG. 20. SECOND-CLASS SMOKING ROOM.

(*To face Page* 9.)

ENGINEERING.

Offices for Publication and Advertisements, 35 and 36, Bedford Street, Strand, London, W.C. 2.

We desire to call the attention of our readers to the fact that the above is our SOLE ADDRESS, and that no connection exists between this Journal and any other publications bearing somewhat similar titles.

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ADVERTISEMENT RATES.

The charge for advertisements classified under the Headings of Appointments Open, Situations Wanted, Tenders, &c., is four shillings for the first four lines or under, and one shilling per line up to one inch. The line averages seven words. When an advertisement measures an inch or more the charge is 12*s.* per inch. Payment must accompany all orders for single advertisements, otherwise their insertion cannot be guaranteed. Terms for displayed advertisements on the wrapper and on the inside pages may be obtained on application. The pages are 12 in. deep and 9 in. wide, divisible into four columns of 2¼ in. in width. Serial advertisements will be inserted with all practicable regularity, but absolute regularity cannot be guaranteed.

TIME FOR RECEIPT OF ADVERTISEMENTS.

Advertisements intended for insertion in the current week's issue must be delivered not later than First Post on Thursday. In consequence of the necessity of going to press early with a portion of the edition, alterations for standing advertisements should be received on the Friday previous to the day of publication.

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ENGINEERING.

FRIDAY, JANUARY 5, 1923.

THE NEW ORGANISATION OF BRITISH RAILWAYS.

IT is no exaggeration to say that the whole mental outlook of this country has changed within the lifetime of the middle-aged. The genesis of the change lies far back in history, and the forerunners who saw better than their fellows may well have thought that the ideals for which they stood made no progress in their lifetime. Gradually, however, a change has come about. It was greatly hastened by the war, and to-day the whole mental attitude of the nation is of an altogether different quality from that of forty to fifty years ago. The new orientation is possibly connected with the new growth of the spirit of nationalism which is evident throughout Europe. It is difficult to describe in set terms, but its effects are written broad across the present day. It may perhaps be described as a new social conscience, and one of its most obvious effects may be seen in the way in which unemployment is looked at and treated as compared with the practice of no great while ago.

To call this new habit of mind a social conscience is perhaps, however, to give it a quality of sympathy and charity which, although not alien to it, is inadequate to explain it properly. The new mental outlook is equally illustrated in the legislation designed to introduce unity and common working into the business of electricity supply or in the amalgamation of our railways into four great groups, and it is not usual to associate either of these proceedings with the ideals for which Charity stands. Her sisters, Faith and Hope, would appear to be nearer the heart of these particular manifestations of the new spirit. This new mental attitude conceives of society as a whole in a way that would have been foreign to the average man of not very many years ago. He would not have readily agreed to the proposition that the nation as a whole cannot afford to allow the deterioration of its workpeople in periods of bad trade and must do all it can to assist them over such stages, which now receives general acceptance as a matter of course. Similarly the jettisoning of cherished ideas about the rights of local government or the benefits of competition is now watched unmoved in view of the new conception of the advantages of common service and unity of effort in electricity supply.

The Railway Act is the latest manifestation of this point of view, and many of the hopes which are associated with the New Year are basing themselves on the service which this Act is to render to the country. One trusts these hopes may not be disappointed. John Bright said "We stand on the shoulders of our forefathers, and see further." In a sense this is probably true of any age; in another it is true of none. But in the looking to the future—the longing for the future—which is characteristic of the time, the phrase has a peculiar appositeness to the day. The nation is looking forward to a better future and is showing much unity and courage in carrying out measures which interpret the new feeling of a common unity.

There is nothing very novel in the idea of uniting a number of enterprises, engaged on a common activity, into a single combine, but there is much novelty in finding this procedure urged by public opinion. A fair amount of trade combination has been seen in this country, and still more in some others, and while the promoters of such combines have usually not failed to point out that they are for the public benefit, public opinion has, as a rule, been of an opposite opinion. Nothing better could illustrate the new spirit and faith of the time than this public belief in combination, which is being carried to the length of forcing such combination on reluctant private companies. This matter need not be interpreted as a conversion to socialism, and it is fairly certain that this type of combination would not be encouraged for other than public services. This aspect of the matter, however, we need not now pursue.

There are both advantages and dangers in the public backing which the railway combinations are receiving. They will begin operations under the ægis of a general goodwill which is a valuable asset, but danger lies in the expectations which this goodwill necessarily carries to a comparatively uninstructed public opinion. A very slight consideration of the problem with which the new organisations have to deal will show that no startling results can be expected immediately, but it is likely to prove difficult to get the public to take this slight consideration. The problem which confronts the staffs of the new companies is sufficiently illustrated by the fact that the London and North-Eastern Railway has a total mileage of 6,700 and covers the combination of six important railways. The London, Midland and Scottish Railway has a mileage of 7,300 and includes seven large companies. That these new organisations should be able to introduce better facilities and make important economies, which were beyond the reach of the original companies, there is no doubt, but it will prevent disappointment if it is realised that they cannot be expected to do a great deal this year or even next.

It is clear that organisations of the size of these must in some way be worked sectionally, and it has already been announced that the London and North-Eastern will be operated under three divisional general managers. Mr. S. A. Parnwell will administer the territory originally covered by the Great Central, the Great Eastern and the Great Northern Railways, Mr. Alex. Wilson that originally served by the North-Eastern Railway, and Mr. J. Calder will deal with the Scottish area, which covers the ground formed by the North British and Great North of Scotland. These divisional general managers will have areas as large as, or larger than, those administered by the general managers of the original constituent companies, which should itself tend to economy, but, in addition, they will have the advantage of acting in conjunction with Mr. R. L. Wedgwood who will act as chief general manager. This arrangement will avoid too much centralisation, but should at the same time give the divisional

managers all the advantages of acting in conjunction with a large central company, of which their area forms a part, instead of with possibly friendly but still independent companies. In the case of the London, Midland and Scottish Railway, Mr. Arthur Watson is to act as general manager of the whole line, and Mr. D. A. Matheson as deputy-general manager for Scotland. All the staff arrangements for this combination are, we think, not yet complete.

Under the new dispensation obvious economies may be achieved in connection with material. It is clear that the number of types of locomotives in use on the London, Midland and Scottish and on the London and North-Eastern Railways will ultimately be reduced, which in itself should tend to economy in manufacture, replacements and the carrying of spares, while sooner or later one may take it that some type of more or less specialised building in the various works will be undertaken. Some of the works will no doubt in time be abandoned, and manufacture concentrated on the most suitable and economic sites. The same kind of thing must take place in connection with carriage building. Reforms and reorganisations of this kind cannot, however, be carried out on a large scale in a hurry and without important çapital expenditure, and it will but lead to disappointment if the public expect to see any very immediate results from movements of this kind. Apart from inherent difficulties, such matters can but move slowly in view of the personal factor which is involved. We have said that the new organisations start out in the light of public goodwill and there is no reason to suppose that the staffs of the constituent companies wish the combinations other than well. When looking for early result however, it is well to realise that the older officials cannot be expected to view the passing of the autonomy of their positions with any particular pleasure, and it must be expected that some of the ordinary inertia of human nature will have to be overcome in carrying through far-reaching changes.

It is more in the direction of increased facilities than important economies that the first fruits of the amalgamation are likely to be seen. These may in themselves carry economies, but they will not be of the magnitude that should be possible in years to come. It is obvious that the amalgamation of what have hitherto been competing routes should make better public service not incompatible with economies. The operation of the two routes between London and Manchester and London and Glasgow, for instance, by a single organisation should result in an arrangement of schedules which will give the public all the service they require and yet will avoid wasteful overlapping. Many other similar cases could be quoted. Something more may no doubt also be done towards increased through services, but in many instances these will still involve operation over the lines of two companies, and in any case a good deal has been done in this direction in recent years. There should, however, obviously, be a considerable extension of the possibility of using the return-halves of tickets over alternate routes, which in many cases is a considerable public convenience. We have no idea what the intentions may be in that direction, but it would appear that a considerable extension of the possibilities of bookng in advance might well be offered to the public. Presumably, some of the present town offices will disappear, but those that remain will become of greater importance, and some may require enlargement. It would appear that pre-booking at these offices might well be encouraged. Some railways in the past had admirable pre-booking systems, but they were not very prominently advertised and passengers were frequently charged extra for the privilege of buying their tickets beforehand. There appears no good reason for this. One is not charged extra for buying a theatre ticket beforehand and it can only be to the advantage of railway companies, especially at busy times, that they should have foreknowledge of a particularly heavy demand on any one day.

A very important feature of the Railway Act has yet to be mentioned. This concerns the limitation of the fund out of which dividends may be paid. Any surplus of revenue beyond that necessary to pay dividends equal to those of 1913 is to be divided into two parts, of which the larger, representing 80 per cent. of the total, is to be expended in reducing charges, the remainder going to increase dividends. This is another application of the valuable system under which it pays a monopoly company to sell their commodity as cheaply as possible. It may be compared with the method under which a gas company is not allowed to increase its dividend beyond a stipulated percentage unless it reduces the price of gas proportionately. The railway companies have now every incentive to work economically and efficiently. We fear, however, they have some way to go before their 20 per cent. share of surplus revenue amounts to any considerable sum. The amalgamations will help them, but labour costs are still a deplorably heavy charge. Wages are based on definite agreements, which in essence must stand, but there is little doubt that much might be done by a commonsense and broad interpretation of the eight-hours' agreement, and it is much to be hoped that the labour unions concerned will be prepared to look at this matter in a fair way and not to insist on the letter when it leads to unjustifiable expense which ultimately falls on the country at large.

THE ENFORCEMENT OF INDUSTRIAL AGREEMENTS.

A SCOTTISH judge (Sheriff J. A. Fleming, K.C.) has issued an important judgment in an action in the Sheriff Court at Dunfermline at the instance of two miners, David Mackenzie and James Scott, against the Fife Coal Company, Limited, on the subject of the legal effect of the terms of settlement of the mining dispute of 1921, which were signed by the Mining Association of Great Britain and the Miners' Federation and also on behalf of the Government. We are interested to see that the Sheriff's views are in general accordance with those expressed in our article of September 8, 1922, on "Industrial Negotiations and Agreements."

The pursuers, or plaintiffs, sued for the sum of 5*l.* 18*s.* 4*d.*, which, they said, was a balance of wages due to them. Their case was (1) that when they were engaged by the Fife Coal Company it was agreed between them and the under-manager that they were to be paid on the make-up system, *i.e.*, they were to be paid at a certain tonnage and yardage rate, but if the wages they earned were less than the county wage the company were to make up the difference; and (2) that, in any event, in accordance with the terms of settlement a minimum wage was provided, and they had not been paid this minimum wage. The company denied that there had been any agreement that the men should be paid on the make-up system, and said that all that their under-manager had agreed to pay was a tonnage and yardage rate. On the second part of the case they said that the terms of settlement did not provide for any minimum wage, and even if the terms of settlememt were in any way relevant to the pursuers' claim they could not be enforced in a court of law. The Sheriff, agreeing with the Sheriff Substitute, has sent the case for proof or trial in order to ascertain what bargain or agreement was made between the men and the company when the men were engaged; but he has also agreed with the Sheriff Substitute in throwing out the case so far as it was based on the terms of settlement.

In dealing with the pursuers' alternative ground of action, viz., that the provisions of the terms of settlement were impliedly incorporated in the contract of employment of the two men, the Sheriff points out that if the pursuers succeed in establishing at the trial that they were engaged on the terms which they allege, they will get all they say they are entitled to under the terms of settlement. On the other hand, if they fail to prove their statements as to the terms on which they were expressly engaged, it will be on the ground that they accepted employment at wages less than the settlement entitles them to; and they cannot claim more wages than they agreed to accept. He then points out, incidentally, that in his opinion the terms of settlement do not provide a minimum wage for each individual worker; and having done this he proceeds to consider whether, if they did contain such a provision, the pursuers could get any benefit from it in their action. He says there is no principle on which he could hold that the terms of settlement, being an agreement between the Mining Association and the Miners' Federation, had been impliedly imported into the men's contract of employment, and he points out that if the company prove their version of the terms on which the men were expressly engaged, these express terms would be contrary to the terms of settlement and would therefore exclude them. Further, he takes the view that the terms of settlement could not be enforced as an agreement in a court of law, on the ground that it is an agreement between one trade union and another.

This view is founded on Section 4 of the Trade Union Act, 1871. That Act provided that trade unions should not for certain purposes be regarded as illegal; but Section 4 provided that nothing in the Act should enable any court to entertain any legal proceedings instituted with the object of directly enforcing any agreement made between one trade union and another. Sheriff Fleming takes the view that the pursuers, by founding on the terms of settlement, are attempting directly to enforce them in a court of law; and he says that that is prohibited by the Act of 1871. With the greatest respect to the learned judge, we think the use of the word "prohibited" is scarcely accurate. It has been repeatedly laid down by the Supreme Courts that the Act does not actually prohibit the enforcement of such agreements in court. It provides merely that nothing in the Act is to entitle any court to entertain such actions. The question of their enforceability is therefore left to the common law, and if either or both of the trade unions concerned is an illegal society at common law, *e.g.*, if its objects are in restraint of trade, the courts will not enforce the agreement. The main point, however, with which we are concerned is that the Sheriff has made it clear that if a man is engaged on certain express terms which happen to be less favourable than the terms arranged in a general industrial agreement between his trade union and his employer's association or trade union, he cannot maintain that the agreement between the two associations or trade unions automatically become a part of the terms on which he was employed and overrode them in so far as they were unfavourable to him. Of course, as the Sheriff has pointed out, the case might have been different if the parties had expressly imported the terms of settlement into their contract. They would then have become a part of the contract, and not a mere agreement between two trade unions, and the court could have enforced them as part of the contract.

It should be unnecessary to add that in discussing these legal questions as we have done, we are certainly far from suggesting that industrial agreements should not be loyally carried out both by employers and by employed.

AIR TRANSPORT.

AT the moment there appears to be little to discuss in connection with air transport except how best to encourage the industry so that we may not be seriously handicapped in the event of war, Commercial aviation as an end in itself will doubtless come in due time, but for the present the need seems to be greater of using it mainly as a means of keeping us, as a nation, at least abreast of the times. Mr. Handley Page, in a paper on the subject, read before the Institute of Transport on Monday last, terms this the military aspect of the question, and we suppose this is at present the correct definition. The actual need for commercial aviation is still very restricted, though it will doubtless become more and more part of our lives as time goes on. In the early days of railways there were probably plenty of people who regarded the new form of locomotion as all very well, but not at all necessary to their existence. The same attitude can easily be remembered as having been adopted towards motor vehicles. But both systems of transport are now indispensable, and although this may not now be so as regards air transport, it is essential for us to keep well up with the art in order that we may be prepared for expansion when the time comes.

The military aspect is now rather more urgent. We had command of the air in the latter stages of the late war, and the problem is how to ensure that all the good work then done shall not need re-doing before we can take up a similar position of superiority in the future. This aspect has been discussed a great

deal in the last few years, but we seem to have arrived at only a partial solution. Mr. Handley Page did not contribute to it much that was new in his paper before the Institute of Transport. The case for subsidies has been frequently stated and we consider to be conclusively established, in view of the need of keeping the industry going. It may be allowable to point out that in new countries pioneering railways are nearly always subsidised in one way or another. In Canada the opening up of the whole of the western provinces was made possible by concessions to tide railways over early fruitless years. In other Colonies where railways are State-owned the deficit is borne by the State and the railway subsidised to this extent. There is no reason why the same principle may not with justice be applied to aviation, which, though perhaps not immediately necessary to our development, must ultimately prove either in war or peace vitally important to our national preservation.

The manner of the subsidy is the real crux at the moment. With the necessity for economy in every direction, expenditure on what resembles at first sight a luxury is naturally decried, while on the other hand, the lavish scale of support accorded to the industry across the Channel also arouses unfavourable criticism of our authorities in many quarters. Whatever the economic limit of the support we can at present allow to aviation, the general policy of this country would appear to have been justified since Mr. Page showed in his paper that, so far as they went, the British services were being operated on a much higher standard than those of other nations. This at least is satisfactory, for, if we cannot have both quantity and quality, the best thing to lay stress upon is undoubtedly high quality.

As regards the future Mr. Handley Page suggests that there is room for improvement in the running costs of the services. It is clear that a very restricted service cannot be made to pay any more in aviation than in other forms of transport. Within reason a small service can be expanded without addition to general charges which bear more lightly on traffic volume. Again, if the paying load could be increased from about 5 lb. per horse-power to something more like 10 lb., the cost per ton-mile for full load would work out at about 1*s.* 6*d.*, instead of the present figure of 3*s.* 6*d.* This, of course, would greatly influence the whole industry, though it may be too early yet to expect a great accession of traffic to follow a decrease in fares. The public need to be educated in the use of air transport, and this will take time. In the meanwhile, provided the services are free from accidents, traffic, we believe, will develop steadily whether the present rates are materially lowered or not.

THE VISCOSITY OF SLURRY IN THE CEMENT INDUSTRY.

THE advantage to be gained by adopting any economical means of increasing the viscosity of raw material slurry in the Portland cement industry is sufficient to warrant serious consideration of the subject. At present, to obtain the degree of viscosity necessary to enable the slurry to be easily handled by pumping, a large quantity of water is mixed with the raw materials. This has ultimately to be got rid of, and any considerable reduction of the water required should as a consequence be reflected in a saving of fuel, if the kilns are really efficient.

It has for some time been known in the ceramic industry that the viscosity of clay slips can be reduced by the addition of certain chemical substances, and this fact has been applied in various ways. Using this information as a basis the British Portland Cement Research Association recently instituted an investigation with the object of ascertaining whether similar applications would prove advantageous in the case of raw material slurry. The results have now been published by the Association, whose address is 6, Lloyd's-avenue, E.C. 3, in the form of a pamphlet which is well worth perusal by those concerned with the industry.

The general results are that some chemicals reduce the viscosity of slurry, while others increase it; others again reduce it if added in small quantities only to increase it if added in larger proportions, or after a lapse of time. The effect is so clearly dependent upon the character of the slurry that it is not possible to formulate definite rules, and the practical side of the idea must be worked out for each grade of slurry employed. The report is sufficiently suggestive to arouse, we think, the interest of the works' chemists and may lead to the elucidation of further points now still obscure. Translated into figures the possible effect of a 4 per cent. reduction of water on an original amount of 40 per cent., with coal at 30*s.* per ton and the necessary chemical at 10*l.* per ton, would be something of the order of 15*s.* 10*d.* per 100 tons of clinker. This, although not large, in these days of high costs, is appreciable, and worth securing. With the same base figures, but with only a 3 per cent. reduction the saving would possibly be no more than 2*s.* 5*d.*, while with a 2 per cent. reduction the cost of the process would outweigh any advantage by more than 10*s.* per 100 tons of clinker. While the economy possible is thus worth consideration, the margin between a net saving and a loss is not large, and at least 4 per cent. reduction in the water would seem a figure to aim at with the particular cost figures given. These figures will vary, and it may be admitted at once that even 4 per cent. does not always appear to be attainable in practice, so far as the investigation has been carried at present. On the other hand, there are indications that it can be exceeded with certain classes of raw materials. Figures of 4 per cent. and 4·3 per cent. have been experimentally attained, and 4·6 per cent. for chalk slurry alone.

In the experimental work the determinations were made on two methods. In one the viscosity of the chemically-treated slurry was compared with slurry to which an increasing proportion of water was added to produce the same viscosity. In the second method the slurry was allowed to settle, and varying amounts of the supernatant liquid were removed and the remainder treated with the chemical. This gave the reduced amount of liquid which, with the chemical, produced a viscosity figure equal to that of the original slurry. In the investigation both determinations were made and the mean taken.

Of a number of substances sodium carbonate would appear to be the most promising chemical to use. Quantities as small as 0·075 per cent. (on the slurry) increase the viscosity so as to render a decrease of water possible. In what follows the viscosity figures relate to the actual viscometer employed, but the values are comparable. Generally speaking the viscosity of slurry tends to increase with keeping; not, however, as a result of separation of water. The addition of 0·075 per cent. sodium carbonate, not only reduces the viscosity, but tends to prevent this thickening with time. In one case slurry showing a viscosity of 8·5 water units when fresh, gave a figure of 29·8 when 30 days old. The original slurry treated with sodium carbonate only showed 4·5 units when fresh, and actually 4 units after 30 days. The effect seems to be one mainly on the chalk, and the varying effect noticed appears to be traceable to the presence in the slurry of calcium and magnesium salts which are precipitated on the addition of sodium carbonate. If such salts are present in large quantities the sodium carbonate is removed from the solution and its beneficial effect on the slurry is thus prevented.

Among other substances covered by the investigation, the value of sodium silicate was examined. This did not improve conditions to the extent found with sodium carbonate, while the effect was first to increase the viscosity before effecting a reduction. Sodium hydrate, on the other hand, first reduced the viscosity, while further additions thickened the slurry considerably. Sodium sulphate effects a reduction, but not to the same extent as sodium carbonate, while sodium chloride was found to be without appreciable effect. Sodium resinate, in the form of a resin soap composed of resin, soda ash and common salt, failed to give any satisfactory result such as is recorded of its use in the ceramic industry. Barium compounds do not appear to offer any advantages, even when used in conjunction with sodium carbonate. All these substances were tried, we understand, because their use in ceramics has been either actually applied, or at least claimed to be successful. The investigation also included trials on the effect of passing an electric current through slurry, but an increase in viscosity only was obtained.

We believe the investigation is to be continued with a view to clearing up, if possible, many points still obscure, but, so far as it has proceeded, the work would appear to have arrived at definite results of some value, though from the data presented it is obvious that each individual case must be the subject of examination by the chemical staff.

THE PHYSICAL AND OPTICAL SOCIETIES' EXHIBITION.

THE thirteenth annual exhibition of electrical, optical and other physical apparatus, arranged by the Physical Society of London and the Optical Society, was held last Wednesday and Thursday, January 3 and 4, from 3 to 10 p.m., at the Imperial College of Science, South Kensington. The arrangements for this exhibition, one of the scientific events of the season, were again in the hands of Mr. F. E. Smith, F.R.S., senior secretary of the Physical Society. Among the 53 manufacturing firms represented, to which four booksellers are to be added, were some new names not generally seen on this occasion, whilst a few of the usual exhibitors were absent. The exhibits were arranged in the various rooms of two floors of the building; a few exhibits had found accommodation in the basement. The descriptive catalogue followed the alphabetical order of the names, a grouping which was certainly most convenient for the visitor; so far as possible cognate exhibits were placed together. Two very interesting experimental discourses were given on the first day and repeated on the second day; the first was by Mr. W. Gamble, on "Reproduction of Colour by Photographic Processes," the second by Professor E. G. Coker, F.R.S., on "Recent Photo-Elastic Researches on Engineering Problems." The attendances fully justified the holding of the exhibition.

Two of the novelties of the Cambridge and Paul Instrument Company, which we notice in the first instance, can only be mentioned in the present article. They are the Galitzin seismograph and the Collins stress recorder, both of which we shall deal with next week. The Automatic Balance for Recording sedimentation is of the type of the balance which Professor Sven Odén, of Upsala, designed for geological and colloidal researches, and which was constructed with the aid of a grant from the Swedish Academy; we have referred to this balance on other occasions. The modification of this instrument, now exhibited as the Odén-Keen balance, is due to Dr. Keen, of the Rothamsted agricultural station, and is made by the Cambridge Company. The instrument looks like a chemical balance, from the one pan of which is suspended a disc, 6 cm. (2·4 in.) in diameter; this disc is lowered into the glass cylinder—which is wider than the disc—containing the suspension to be studied; as the particles settle on the disc, the latter sinks. In the old instrument this sinking raised the other pan and caused a ball to drop out of it; a point was then recorded electrically, and the rate of sedimentation was thus registered. But the instrument did not give a continuous curve. To obtain this, the ball-dropping device has been replaced by a solenoid with plunger, and a continuous curve is drawn by a kind of Callendar recorder. The instrument shown, which was made for Professor Odén, records sedimentation to a total weight of 5 grammes, and readings up to 0·001 gramme can be estimated on the chart, which has a width of 125 mm. (5 in.).

The Revolving Camera, also made by the firm, is based upon drawings supplied by the Bureau of Standards of Washington to the National Physical Laboratory, by permission of which the camera was shown. The camera records photographically, *e.g.*, the surgings in current potential and intensity set up in a Duddell oscillograph when a heavy current oil switch is being operated. For testing three-phase phenomena three drums are required. The aluminium drum of the camera, 320 mm. in diameter,

rotates within an aluminium box fitted with a shutter and a cylindrical lens of 74 mm. aperture. The drum round which the film is wrapped is 150 mm. long and has a circumference of 1 m. (a little more than a yard); it is rotated by means of a pulley and is also traversed by means of a magnetic clutch. A time scale of 0·01 second is marked on the film; the camera shutter is electrically in parallel to the clutch; the three drums have to be kept in synchronism. Various striking curves were exhibited.

The Voltmeter of Mr. E. B. Moullin, M.A., of the Cambridge University Engineering Laboratory, has been designed for measuring potential differences of only a few volts at high frequency. The difficulty of all such measurements is that the introduction of the measuring device, mostly a hot wire or a dynamometer, alters the characteristics of the low-volt circuits, even of direct currents. At high frequency the impedance of the dynamometer windings becomes prohibitive, and the capacity of an electrostatic instrument would be comparable to that of the high-frequency circuit itself. Mr. Moullin's instrument is a combination of a triode valve with a moving-coil direct-current galvanometer; the capacity of the combination is negligible, and there is practically no absorption of power; the readings are unaffected by the frequency of the applied potential. The valve serves as a current-rectifier in its own peculiar way and may be utilised by different methods. Mr. Moullin first used the "slide-back" method, connecting the valve with an anode battery and a potentiometer. When no electromotive force is applied, the grid is made more and more negative until the galvanometer in the anode circuit is brought to zero. When the potential is now applied, current will flow, because the positive-half cycle current—a few microwatts on a 7-volt circuit in this case—exceeds the negative half. By making the grid more negative, we can reduce the positive current to zero again; but the "slide-back" may have exceeded its proper value, and the measurements may be misleading. Mr. Moullin hence adopted the two methods illustrated in Figs. 1 and 2 annexed.

In the triode, rectification can be obtained with the aid of the curvature of either the anode-grid/current-potential characteristic (method A, Fig. 1) or of the grid-current/grid-potential characteristic (method B, Fig. 2). In the A voltmeter the valve, galvanometer and auxiliary apparatus are mounted in a small case, and it is only necessary to connect a 6-volt battery to the filament terminals and to apply the potential to be measured at the terminals shown. The scale of the sensitive unipivot-galvanometer G is marked in volts, the standard range being 0 volt to 1·6 volts; readings can be taken to 0·02 volt. This type A cannot measure alternating potentials superposed on steady potentials, nor can it be used when the apparatus joined in does not form part of a closed conducting circuit. In such cases type B is used. In this, as will be seen in Fig. 2, an anode battery of about 70 volts is added to the parts wanted in case A. The scale ranges up to 10 volts, and readings can be taken within half a volt. Both arrangements are suitable for measuring low- and high-frequency volts and also small inductances, the current amplification produced by triode amplifiers and the strength of signals; type B is further suitable for the determination of the power-factor of condensers and aerials. With an inductance of 10,000 microhenrys and a frequency of 10^5 periods per second, a current of about 160 microamperes will produce 1 volt across the terminals.

The triode valve is now widely used as a source of alternating currents of small intensity for testing and measuring purposes, because it gives currents of constant amplitude and frequency, while admitting of variations of the frequency through wide ranges.

The Valve Generator exhibited by the Cambridge and Paul Instrument Company is intended to supply the currents for bridge, inductance and capacity-testing. At the exhibition demonstrations by the Moullin voltmeter were used for measuring the currents of some of these valve generators. The latter are made with two sets of windings, one for frequencies of 300 maximum (a vibration galvanometer is used in this case), and the other for higher frequencies. The instrument is encased in a small box, into which, when low frequencies are to be measured, a cylindrical iron core, made up of vertical laminated sheets, is lowered.

Two kinds of Electrically-maintained Tuning Forks were exhibited by the firm. The first is due to Professor W. H. Eccles and Mr. F. W. Jordan; its principle was explained by Dr. Eccles in his lectures on the "Thermionic Tube" which we noticed on pages 724 and 725 of our issue of May 28, 1920, and to which we may refer our readers with respect to the valve characteristics. The instrument is to generate currents suitable for measuring the magnifying power of valve amplifiers—800 cycles were used in the demonstration. The fork is mounted with its prongs between the polarised windings on laminated cores which are carried on two electromagnets, the one coil being connected to the grid, the other to the valve anode. The variation of the grid potential gives rise to variations in the anode current of the same frequency. When this current is of correct phase relation with the motion of the prong of the fork, it provides a vibro-motive force in traversing the anode windings.

Fig. 1.

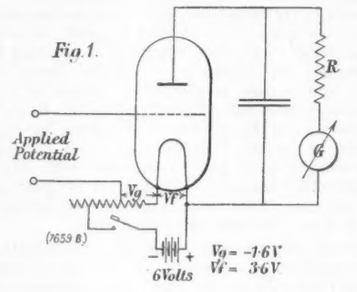
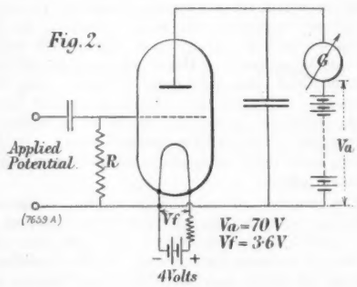


Fig. 2.



A transformer separates the generated alternating potential from the direct potential. The instrument runs steadily all day long, and may be restarted at the same rate on another day, provided the temperature has not changed meanwhile. To start it, the current from two cells has merely to be switched on. The instrument may be likened to an electric bell, the contact of which is replaced by a valve.

The second instrument, the reed hummer of Mr. S. A. Pollock, is intended to produce oscillations of audio-frequency. The device, which has been adopted by the Post Office for telephonic measurements by bridges, will also run for hours without attention; it is simple and does not require a valve. A permanent magnet is so mounted, together with a steel reed, on a heavy brass base, that the reed forms the magnet armature; coils are wound on the pole tips, and a microphone button is attached to the reed. The circuit is tuned with the aid of a transformer and two condensers, inside the instrument case. When the reed vibrates, the disturbance set up in the microphone produces a varying current in the magnet coils which reacts on the reed and maintains its rate of vibration. When the instrument terminals are connected with a screened transformer, which forms a separate unit, an output circuit is obtained which, joined to a bridge, prevents out-of-balance capacity effects at the salient points of the bridge. Similar instruments were exhibited by various other firms, and we have therefore given a somewhat full explanation.

The other exhibits by the Cambridge and Paul Company have already been noticed in ENGINEERING. The Cambridge (Collins) micro-indicator was shown at work on an engine, and we may mention that some of the somewhat rough indicator diagrams which we illustrated in our issue of June 9 last, page 716, were taken with the early models of the instrument. Any peculiarities of the diagrams produced are not due to the vibrations of the little celluloid disc or to other imperfections of the instrument as actually put on the market.

(To be continued.)

NOTES.

A SHORT RECORD OF 130 YEARS.

The archaeologist of to-day draws his conclusions as to former civilisations from the ruins of ancient cities or from the tombs of forgotten kings. When our own civilisation is the subject of investigation by the archaeologists of the future they will have the advantage of such newspapers as may have been preserved, and with their assistance will no doubt produce some wonderful accounts of how mankind lived during the present era. Should they alight on a copy of the handsome souvenir recently published by our esteemed contemporary *The Observer* to mark the completion of 130 years of vigorous life, they will find a most interesting summary of the political events of the period, but will certainly wonder at the prominence given to such matters to the exclusion of all reference to scientific and industrial progress. When *The Observer* first surveyed the world, in 1791, James Watt was busy making the condensing steam engine a practical machine, neither the steamship nor the locomotive existed and neither transportation nor industry as we known them to-day were even conceivable. The period covered by the review, saw the invention of the electric telegraph, the submarine cable, the Bessemer process, the electric light, the motor car, the aeroplane, wireless telegraphy and telephony, the X-rays, the production of synthetic chemicals, the discovery of bacteriological action and hosts of other inventions which will occur to the mind. It is these which have fashioned the civilisation of to-day or, rather, which have made it possible to exist at all, and not the transactions of lawyers and politicians. We fully appreciate the doings of the latter and the skill with which our contemporary has presented a summary of the events in which they figured, but to omit all reference whatever to the inventions which enable *The Observer* to gather its news from the ends of the earth, print it, and to distribute it to every hamlet in the land on Sunday morning is surely a fault in a "short record of one hundred and thirty years."

SCIENTIFIC NOVELTIES EXHIBITION.

The colleges and schools of the London University have joined with the Polytechnics, the Royal Microscopic Society, the Photomicrographic Society and the Queckett Club in the promotion of an exhibition of scientific novelties for the benefit of the Hospitals of London Combined Appeal Fund. The exhibition is being held in King's College, Strand, and was opened by the Right Honourable Viscount Burnham on Thursday, December 28. It will remain open every afternoon and evening until January 10. The main part of the show is divided up into sections devoted to wireless, engineering, physics, chemistry, biology and geology, but the Egyptian exhibits of Professor Flinders Petrie and the demonstrations of psychological and physiological tests also attract a considerable amount of attention. Whatever can be used to demonstrate in an unusually impressive manner many of the physical and chemical actions with which we are familiar, is here available, and a very interesting time may be spent by any visitor. On the engineering side, Mr. W. C. Clinton and Dr. Moule, of the University College, give demonstrations of rotating and repulsion actions in alternating magnetic fields and metals boiling in the electric arc, and Professor E. Wilson, of King's College, performs experiments with high-tension discharges and has organised a display of electric arc, resistance and spot welding and of automatic telephony. The East London College, Northampton Institute and Regent-street Polytechnic have sent exhibits to show the many types of electric lamps, their history and development. Singing flames, travelling air bubbles in liquids, rectifiers, the examination of water jets by means of a stroboscope,

the paths of a rays and the historic apparatus in the museums and some of the laboratories—are all shown and command attention. A display of wireless apparatus in use broadcasting is very popular. Many interesting lectures, three or four of which are given each day while the exhibition is open, provide an added interest to what we hope will prove a very successful effort to assist a deserving cause.

The Report of the Electricity Commissioners.

We trust that it is not too much to hope that in time to come the annual reports of the Electricity Commissioners will present year by year a comprehensive review of the electricity supply industry in Great Britain with such technical and financial statistics as will enable the position and progress of the industry to be readily understood. At present they are far from such an ideal, being concerned rather with what the Commissioners are doing in their endeavour to retrieve the industry from the unsatisfactory conditions which had grown up as a result of previous unwise legislation. The second annual report which has just been issued deals with the work of the twelve months ending March 31, 1922. It contains little of technical interest, but we note that there are in Great Britain (exclusive of Ireland) 531 authorised electricity undertakings, a complete list of which, together with particulars of area served, maximum prices, &c., is being prepared for separate publication. During the year the Commissioners received returns from 433 generating stations belonging to authorised undertakers and from 103 stations owned by tramway or railway authorities or non-statutory undertakings. Of these 536 stations, no fewer than 232 generated less than 1,000,000 kw.h. during the year. Assuming a load-factor of 20 per cent., this means that nearly half the power stations in the country only carry a maximum load of less than 6,000 kw. during a year. The aggregate amount of electricity generated by the 536 stations was 4,884,666,038 kw.h. for a total consumption of 6,475,531 tons of coal and coke and 145,541 tons of oil. A small proportion of the current was generated by water power, but particulars of this are not given. An appendix to the report gives the conclusions of the Commissioners with regard to the following districts: (*a*) Mersey and West Lancashire, (*b*) North Wales and Chester, (*c*) West Riding, Aire and Calder, (*d*) London and Home Counties, (*e*) South-West Midlands, and (*f*) South-East Lancashire. In the case of the London District the Commissioners give a reasoned statement of their decisions, but the tardiness in the publication of the report robs these and other matters of much of their novelty. The report is issued from H.M. Stationery Office at the price of 2*s.* 6*d.* net.

Dangers in the Use of Acetylene.

Like many other things with which the engineer has to deal, acetylene gas is a good servant but a bad master. Its services are indeed invaluable for many classes of work, such as the welding and cutting of metals, and with the rapid extension of its employment there has naturally been a considerable increase in the number of accidents arising either from defective plant or from carelessness or inadvertence on the part of the operator. These usually take the form of explosions, and in order to minimise the destruction of life and property which such accidents cause, the Factory Department of the Home Office have issued a small pamphlet dealing with the subject. This is entitled "Memorandum on Dangers from the Use of Acetylene Gas and in Oxy-Acetylene Welding in Factories," and is published by H.M. Stationery Office at the price of one penny. Like other publications from the same department, it is of a practical nature and might well be placed in the hands of all who operate acetylene apparatus. Although the precautions to be taken in order to avoid explosions are mostly covered by the application of common sense, this is a characteristic which is often wanting, and continual vigilance is required to ensure that rules and regulations are adhered to. Familiarity breeds contempt even in those who appreciate the possible dangers of explosive gas, and the ordinary workman can hardly be expected to understand that acetylene will form a detonating compound with copper, or that the gas alone is liable to explode if compressed to a very moderate pressure. The great preventive of explosions, however, consists in the most ample ventilation and in care as regards sparks and naked lights. Acetylene present to the extent of only 5 per cent. forms an explosive mixture with air, and ignition takes place spontaneously if the temperature exceeds 480 deg. C. Many accidents are caused by the stoppage of the blowpipe nozzle by a bead of metal, in the case of low-pressure plants. This has the effect of causing the oxygen, which is under greater pressure than the acetylene, to flow into the acetylene supply pipe, forming an explosive mixture which becomes ignited at the jet and results in a "back-fire." To prevent such explosions from reaching the generator, hydraulic valves should be interposed, and these should be inspected every morning to see that they are properly charged with water. The memoranda also alludes to the danger of oil or fatty matter being used to lubricate valves and fittings where it can come into contact with compressed oxygen. Altogether the brochure serves as a useful reminder to those who know, and as a valuable instructor to those who don't.

LITERATURE.

Brassey's Naval and Shipping Annual, 1923. Edited by Sir Alexander Richardson, M.P., and Archibald Hurd. London: William Clowes and Sons, Limited. [Price 25*s.* net.]

Maritime affairs in the year which has just ended have afforded plenty of material for consideration and comment. In naval affairs, the proceedings at the Washington Conference, and in mercantile matters, the unprecedented slumps in freights and shipbuilding, have in themselves furnished texts for many essays, and it is no surprise to find the present issue of "Brassey's Naval and Shipping Annual" of unusual interest and importance. As one has come to expect in connection with this publication, a striking and authoritative list of contributors has been got together, and to mention but one or two examples, great interest is likely to be taken in Admiral Sturdee's chapter on the "Naval Aspects of the Washington Conference," and Sir George Thurston's on "The Influence of the Washington Conference on Naval Design," in the Naval Section, and in those on "The World's Mercantile Marine," by Sir Westcott Abell, and "Shipowners and Shipbuilders," by Lord Inchcape, in the Merchant Shipping Section.

The first chapter of the volume, by Commander C. N. Robinson, is devoted to the annual survey of the British Navy which this author has contributed over many years. Necessarily some reference is made to the Washington Conference and its effects, but the main purpose of the chapter is to review the various activities of the British Navy over the year, and to record the changes which have taken place. The various Admiralty and fleet changes are dealt with, and an account is given of such new construction as has been carried out, the new arrangements in connection with oil-fuel stations, dockyard reductions, &c. This is the chapter of the Annual in which the matter of naval *personnel* is dealt with, and a full account of the effect of naval reductions on both officers and men is given, together with information about training courses, promotion, &c. "Foreign Navies" are dealt with in the same way, but necessarily in somewhat less detail, by Mr. John Leyland, in the second chapter. It is not possible to review the contents of this chapter in the space at our disposal, but it is interesting and not very satisfactory to note, from Mr. Leyland's section dealing with Brazil, that the navy of that country appears to have passed under the tutelage of the United States.

The third chapter of the book, contributed by the editors, takes the form of an analysis by means of tables of comparative naval strengths throughout the world, and is followed by Admiral Sturdee's chapter to which we have already referred. Admiral Sturdee accepts the results of the Washington Conference as "an important advance in the cause of peace." In the next chapter, however, Sir George Thurston, who naturally deals with the matter from the point of view of the naval architect, adopts a somewhat more critical attitude and considers that there is a large element of truth in the statement that the result of the Conference "signifies definite abandonment of the Two-Power standard, and the consequent loss of British supremacy at sea." Sir George points out the serious hindrance to development which is involved in the limitation of battleship displacement to 35,000 tons, and, considering the questions of battleship design which the new conditions introduce, works out three proposals for ships to come within the Conference limits to meet different specifications of service. These designs, which are illustrated by drawings by Mr. Percy F. S. Spence, are of great interest.

The next chapter is formed by an important article on "The French Navy in the War and after the War," from the pen of Capitaine A. Delpierre. In the course of this chapter a careful account and explanation of the Castex incident is given, and it is shown that Lord Lee's famous quotation was given a wrong meaning from the omission of the context. A general analysis of French naval opinion is given and an explanation of its leaning towards the submarine. Capitaine Delpierre shares Sir George Thurston's dissatisfaction with the tonnage limit of the Washington Conference, and states that French opinion is that the 35,000 ton limit "does not allow of a satisfactory solution of the protection problem." Other contributions in this section include a chapter on "Cruisers and Naval Warfare," by Rear-Admiral W. H. D'Oyly, one on "Sea Power and Air Power," by Commander C. Dennis Burney, and another on "The Material Resources of Naval Defence," by the editors, "The Strategic Problem of the Pacific," by Mr. Archibald Colbeck, and "The Principles of Imperial Naval Defence," by Commander H. Rundle. There is also a very interesting account of "The Royal Corps of Naval Constructors," by Sir Eustace d'Eyncourt. In their article on "The Material Resources of Naval Defence," the editors describe the complexity of the plant and organisation necessary for the building and upkeep of a navy such as ours, and touch on the difficult problem which is presented to those who control such plants and organisations, by the long period of insufficient employment which must result from the Washington agreement.

The Merchant Shipping Section opens with one of Sir Westcott Abell's authoritative articles dealing with the "World's Mercantile Marine." This forms an acute analysis of the causes of the present shipping depression, and leads up to the opinion that "in all probability, about 3,000,000 tons of war-built vessels, a million or more tons of normally obsolete ships, and a million tons which have become obsolete owing to recent developments, will have to be disposed of before the world's fleet approximates to the pre-war standard of efficiency." Sir Westcott has more than once expressed the view and demonstrated that one of the main causes of the shipping depression is to be found in the excess of ships above requirements. In the chapter with which we are concerned he goes to the extent of saying that "the cold light of history will ultimately reveal America's war-time shipbuilding, stripped of its cloak of sentiment, as a force almost as unsettling in its effects upon world mercantile conditions as Germany's intense and barbarous submarine campaign of destruction." Sir Westcott's article is followed by one which enlarges on a branch of his subject. This is on "The Freight Depression," by Mr. R. W. Johnson. The information it contains is likely to surprise those who are not connected with merchant shipping.

Succeeding chapters are "Shipowners and Shipbuilders," by Lord Inchcape, which contains a valuable analysis of ship types. This is of great interest as coming from such an eminent shipowner. It is followed by a chapter on "Marine Machinery in 1922," by Mr. James Richardson, who this year devotes a considerable proportion of his space to the marine gear problem. He does not, however, neglect the Diesel engine, which is everyday becoming of more importance in the merchant shipping world. The contribution on "Economic aspects of the Modern Cargo Steamer," by Mr. John Anderson, carries on Lord Inchcape's subject, and to some

extent also does that by Mr. F. A. Hook, on "The Economics of Travel by Sea." These three articles form an interesting discussion of a subject little understood by the layman. The section also includes "British Shipping on the Danube," by Sir Frederick Lewis, "Safety of Life at Sea," by Sir Alan Anderson, "Pilotage and Pilots,' by Captain Harry Davis, and other interesting contributions by specialists in the particular branch of the shipping industry with which they deal.

The appendices have this year been considerably extended by the inclusion of a striking section which gives profiles of the principal men-of-war of all classes in the world's fleets and of representative merchant vessels. This section covers 44 pages and gives some 360 profiles illustrating about 650 vessels in all. The figures have been prepared under the direction of Mr. Arthur J. W. Burgess, R.I., who acts as art editor for the volume. These profiles will be of great value in enabling ships to be identified at a distance, and should be of interest to those who travel by sea as well as others. In addition to the large amount of statistical and other information on the world's navies which has long been an important feature of "Brassey," and the more or less corresponding information dealing with the world's merchant fleets, which has been added in recent years, the present volume also contains a reprint of the Washington Treaty which will be of value for purposes of reference. The merchant shipping appendix includes lists of technical societies concerned with marine matters, naval and shipping organisations, British and foreign shipowners and shipbuilders, steamship services, &c. No trouble appears to have been shirked which was likely to add to the value of the volume, and this thirty-fourth issue of the Annual certainly in every way maintains and carries on the high reputation which the work has established.

American Fuels. By RAYMOND FOSS BACON and WILLIAM ALLEN HAMOR, of the Mellon Institute of Industrial Research of the University of Pittsburgh, New York: McGraw-Hill Book Company, Inc., 1922. Two Vols. [Price 3*l.* net.]

THE aim of the compilers of these two volumes, in which they have received the collaboration of a number of American fuel authorities, is not so much to cover the same ground as other works on fuels, which are already available, but to condense the experience of various specialists within separate chapters. The two gentlemen whose names appear under the title, separated from it by the word "by," might be taken to be the authors of the whole work, despite the addendum, "with the collaboration of specialists." When they refer to themselves as editors in the preface, they have not cleared up their position in regard to the book, for they only accept that position with the reservation that "they are not responsible for opinions expressed by their collaborators." The only matter from their pen in the first volume is the preface, and of the total twenty-six chapters in the two volumes, only one is contributed by them in partnership; but there is another article from the pen of Mr. Hamor. Authorship, or even editorship, of books under these interesting conditions seems to possess many obvious advantages. The bringing together of papers on the various fuel questions is, however, quite commendable, and such a book must have a wide circle of readers among those who look for authoritative statements on the present-day position of the various fuel developments. All the chapters are written with the outlook that it is the engineer and industrialist that is catered for, and not the chemist.

Although limited to American activities, the work is none the less interesting to the workers in this field in our own country. Within such a large field as that of North America, extensive areas bearing every type of fuel in the wood-coal series are to be found. This covers more than we have in Britain, for some of the series are only found here in small quantities, although they are available on a very large scale in the Dominions. In liquid fuel America is, of course, very rich. With her resources much more varied than ours, but covering most of the types of fuel we are familiar with, American practice is useful study to the British engineer.

The first volume opens with a chapter on the coals of the United States, by Marius R. Campbell, which is followed by one by Arthur D. Pratt on the Principles of Combustion. After thus disposing of the essential and fundamental characteristics of the fuels and their burning, the other chapters are devoted to technical uses, such as coke production, briquetting, gasification, utilisation of by-products, distillation of coal at low temperatures, pulverised coal, wood as fuel, fuel oil, natural gas, blast-furnace gases, surface combustion, and colloidal fuel. The progress made in America in treating solid coal for the production of all the derivatives obtainable from the fuel, and the utilisation of the solid residue and gaseous fuel for domestic and industrial purposes, is indicated throughout the work. The resolve of all the fuel authorities of the world to obtain heat efficiently and only after the substances available for chemical and other industries have been distilled off, will ultimately produce improved living conditions in our cities. With the progress now being made it may not be very long before it will be regarded as a criminal offence to burn untreated coal within city areas.

Colloidal fuel, or the combination of pulverised carbonaceous matter with a liquid hydrocarbon, to form a stable atomisable fuel, is perhaps the latest of the many ventures to reduce waste. There are economic and operative advantages to be obtained with a fuel of this character over solid fuel. The division line between the actual molecular solution and mechanical suspension is, of course, arbitrary, but colloids can be passed through filter paper without any appreciable loss of particles, whereas suspended bodies in a mere mixture would be retained. Pulverised coal has many useful properties in steam-raising practice, but its use on board ship has the disadvantage of the great bulk, compared with that of the amount of oil required to produce the same number of heat units. In the field of study of colloidal fuels we owe much to Lindon Bates and his associates in America. Semi-bituminous and lignite coals are the most suitable for the production of colloids. In the chapter on this subject some of the results of the American tests on U.S.S. Gem are given, and show the measure of success attained.

In such a case as this, with the twenty-six different articles, review is somewhat difficult, but we can say that the compilers have shown great discrimination in selecting their authors, and the work is to be commended to all who are interested in any of the new investigations into fuel, for here they will find the story of the American side of the work, and, generally speaking, find it well told.

BOOKS RECEIVED.

United States Geological Survey, Mineral Resources of the United States. I: 9: *Bauxite and Aluminium in* 1921. By JAMES M. HILL. I: 10: *Tin in* 1921. By B. L. JOHNSON. I: 12: *Quicksilver in* 1921. By F. L. RANSOME. *With a Supplementary Bibliography.* By ISABEL P. EVANS. II: 13: *Asphalt and Related Bitumens in* 1921. By K. W. COTTRELL. II: 14: *Mica in* 1921. By B. H. STODDARD. II: 15: *Magnesite in* 1921. By CHARLES G. YALE. II: 16: *Gypsum in* 1921. By K. W. COTTRELL. II: 17: *Talc and Soapstone in* 1921. By E. SAMPSON. II: 33: *Clay-working Industries, Clay and Silica Brick in* 1919 *and* 1920. By J. MIDDLETON. Washington: Government Printing Office.

United States Department of Commerce, Bureau of Foreign and Domestic Commerce. Statistical Abstract of the United States, 1921. Compiled by EDWARD WHITNEY. Washington: Government Printing Office. [Price 75 cents.]

United States Geological Survey. Bulletin No. 707. *Guide Book of the Western United States.* Part E. *The Denver and Rio Grande Western Route.* By MARIUS R. CAMPBELL. [Price 1 dol.] Professional Paper No. 131—A. *Additions to the Flora of the Wilcox Group.* By EDWARD WILBER BERRY. Washington: Government Printing Office.

Taschenbuch fur Pratische Geometrie. By H. LÖSCHNER. Berlin and Leipzig: Walter de Gruyter and Co.

Taschenbuch für den Fabrikbetrich. By Professor H. DUBBEL. Berlin: Julius Springer. [Price 15*s.* 10*s.*]

University of Illinois. Engineering Experiment Station. Bulletin No. 132. *A Study of Coal Mine Haulage in Illinois.* By H. H. STOLK and others. No. 133. *A Study of Explosions of Gaseous Mixtures.* By A. P. KRATZ and C. Z. ROSECRANS. Urbana: University of Illinois. [Price 55 cents.]

Department of Scientific and Industrial Research. Fuel Research Board. Technical Paper No. 5. *An Apparatus for the Measurement of Specific Gravity of Gases in Small Quantities.* By ALFRED BLACKIE, M.A. London, Manchester, Cardiff and Edinburgh: His Majesty's Stationery Office. [Price 4*d.* post free.]

Forgeage et Laminage. By LEON GEUZE. Paris: J. B. Baillière et Fils. [Price 30 francs.]

Imperial Institute. Monographs on Mineral Resources, with Special Reference to the British Empire. Molybdenum Ores. By R. H. RASTALL, Sc.D., M.Inst.M.M., F.G.S. London: John Murray. [Price 5*s.* net.]

Die Unterseeboote der Germaniawerft. By Dr. Ing. H. TECHEL. Berlin: Verlag des Vereines deutscher Ingenieure und Julius Springer. [Price 5*s.*]

Ice and Cold Storage Trades' Directory and Handbook, 1923. London: Iliffe and Sons, Limited. [Price 10*s.* 6*d.* net]

American Malleable Cast-Iron. By H. A. SCHWARTZ. First edition. Cleveland, Ohio, and London: The Penton Publishing Company. [Price 35*s.* net.]

The Theory of Emulsions and Emulsifications. By WILLIAM CLAYTON, D.Sc., F.I.C. London: J. and A. Churchill. [Price 9*s.* 6*d.* net.]

The British Journal Photographic Almanac and Photographers' Daily Companion, 1923. Edited by GEORGE E. BROWN, F.I.C. London: Henry Greenwood and Co., Limited. [Price 2*s.* net.]

A New Manual of Logarithms to Seven Places of Decimals. Edited by Dr. BRUHUS. Thirteenth stereotype edition. London: Chapman and Hall, Limited. [Price 12*s.* 6*d.* net.]

Mechanical Testing. Vol. II. *Testing of Prime Movers, Machines, Structures and Engineering Apparatus.* By R. G. BATSON, M.Inst.C.E., M.I.Mech.E., and J. H. HYDE, A.M.Inst.C.E., M.I.A.E., A.M.I.Mech.E. London: Chapman and Hall, Limited. [Price 25*s.* net.]

Norrland. The Land of Forests, Waterfalls and Iron Mountains. A Study in Economic Geography. By HANS W:SON AHLMANN, Ph.D. Stockholm: The General Export Association of Sweden. [Price 4 kronor.]

Who's Who in Engineering, Directory and Manual, 1923. Edited by JOHN ED. SEARS, Junior, C.B.E., M.A., M.I.Mech.E., F.Inst.P. Third edition. London: The Compendium Publishing Company. [Price 28*s.* net.]

Notes on the Design, Construction and Working of Vessels subjected to Steam Pressure. Manchester: The National Boiler and General Insurance Company, Limited. [Price 2*s.* net.]

Air Publication. No. 913. *Universal Camera Mounting* [Price 1*s.* 1*d.* post free.] No. 916. *Rigging Notes, Avro Biplane, Type* 504K (100 *h.p. Monosoupape*). [Price 7*d.* post free.] London, Manchester, Cardiff and Edinburgh: His Majesty's Stationery Office.

Vector Calculus, with Applications to Physics. By JAMES BYRNIE SHAW. London: Constable and Co., Limited. [Price 14*s.* net.]

Structural Steelwork. By WM. H. BLACK. London: Sir Isaac Pitman and Sons, Limited. [Price 2*s.* 6*d.* net.]

Internal Combustion Engines. By J. OKILL, M.Eng. London: Sir Isaac Pitman and Sons, Limited. [Price 3*s.* net.]

Calvert's Mechanic's Almanack, 1923. Edited by FRANK NASMITH and JAMES MCLACHLAN. Manchester and London: John Heywood, Limited. [Price 6*d.* net.]

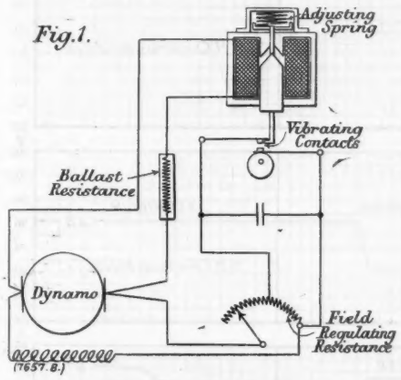
The Practical Engineer Electrical Pocket Book and Diary, 1923. Edited by CONRAD ARNOLD, A.M.I.E.E. London: Henry Frowde and Hodder and Stoughton. [Price 2*s.* 6*d.* net.]

THE INSTITUTION OF MECHANICAL ENGINEERS.—A symposium of papers on "Indicators" is to form the subject of the meeting of this Institution on Friday, the 19th inst., at 6 p.m., at the Institution Building, Storey's Gate, Westminster. Four papers are to be read, as follows: "The Problem of the Engine Indicator," by Mr. L. Pendred; "A New Form of Optical Indicator," by Professor Burstall; "A Micro-Indicator for High-Speed Engines," by Mr. W. G. Collins; and "R.A.F. Electrical Indicator for High-Speed Internal-Combustion Engines and Gauge for Maximum Pressures," by Mr. H. Wood, R.A.F.

NEW YEAR HONOURS.—While the announcements of New Year honours conferred by His Majesty do not include the political list, being confined chiefly to those who have performed service either at home or in the Dominions, it will be seen from the names appended that several important engineers have participated. Knighthoods are to be conferred upon Mr. Edward Manville, J.P., M.Inst.E.E., M.P., for services to the Board of Trade; upon Colonel Charles Morgan, C.B.E., Member of the Disposals Board; and upon Colonel William Waghorn, C.B., C.M.G., of the Royal Engineers, and President of the Indian Railway Board. Engineer Rear-Admiral Wm. C. Sanders, D.S.O., has been appointed a C.B. in the Military Division, while Mr. J. H. Narbeth, C.B.E., M.V.O., Assistant-Director of Naval Construction, Admiralty, has received a C.B. in the Civil Division. In the Colonial List appears the name of Mr. C. L. N. Felling, General Manager of the Uganda Railway, who, for his services as Chief Assistant to the General Manager of Railways and Harbours, Union of South Africa, will receive the C.M.G. Among the British Empire Orders, a C.B.E. will be conferred upon Mr. W. G. J. Hill, Assistant Superintendent, Staff, Railways and Harbours, Union of South Africa. Mr. E. A. Harris, Superintendent, Mechanical Transport, Ministry of Communications and Works, Iraq, will receive a Membership of the same Order. Upon Mr. Arnold A. Mustof who occupies the position of Executive Engineer, P.W.D., Bombay, will be conferred a C.I.E. The same honour is to be bestowed upon Mr. Naoroji Bapooji Saklatwala, of Messrs. Tata and Sons, Limited, of Bombay. Among the Naval Awards, Engineer-Captain George W. Baldwin, R.N., will receive the C.B.E., as will also (in the Civil Division) Mr. Frank E. Smith, Director of Scientific Research, Admiralty.

AUTOMATIC VOLTAGE REGULATOR FOR DIRECT CURRENT GENERATORS.

AN ingenious and simple voltage regulator suitable for use in connection with small direct-current electric generators—up to a capacity of 50 kw.—is illustrated in the accompanying figures. The device, which is being manufactured by Messrs. Isenthal and Co., Limited, of Denzil Works, Willesden, N.W. 10, is likely to be particularly useful for application to dynamos driven by petrol engines, the speed of which is subject to considerable fluctuations. Small machines supplying circuits containing motors may in many cases also profitably be fitted, as in such cases the voltage is liable to fall considerably when a motor is being started-up. The regulator also permits of the driving of



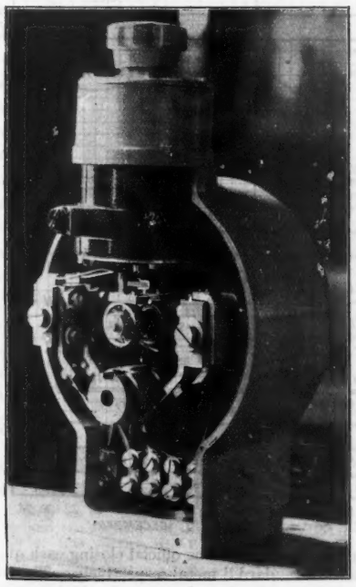


FIG. 2.

dynamos by engines fitted with only primitive governors which would normally be unsuitable for electricity supply.

The appliance utilises the principle of intermittent contact which is used in the Tirrill regulator. There is a pair of vibrating contacts which periodically short-circuit and open the field resistance of the dynamo, while a solenoid, which operates in response to the dynamo voltage, determines the relative positions of these contacts and consequently the period of short-circuit. This introduces a short-circuit time factor as a function of the supplied voltage and results in such regulation of the field that that voltage is kept constant. The arrangement is mechanically and electrically a simple one, and will be followed from the figures. The various items concerned are shown in a diagrammatic way in Fig. 1. The vibrating contacts which are connected across the field resistance are carried by flat steel springs. The spring of the lower contact rests on an eccentric which is keyed to the dynamo shaft, so that as the dynamo rotates the contact is rapidly vibrated and constantly makes and breaks connection with the upper contact. This upper contact is attached to the plunger of a solenoid, the winding of which is connected across the machine, so that the position of the plunger and consequently of the upper contact varies according to voltage. Alteration in position of the contact alters the period of short-circuit. A helical spring is fixed above the plunger which enables the appliance to be adjusted and a condenser is connected across the short-circuiting contacts to prevent sparking.

The general appearance of the regulator is well shown in Fig. 2. It is mounted in a cast-iron casing which is carried either from the machine frame, or on a cast-iron pedestal. It is mounted at the end of the machine shaft in order to get the necessary eccentric drive in a simple way, but a more indirect drive could no doubt be worked out if in any particular case this proved necessary. A double-throw switch is mounted on the regulator case, which enables the polarity of the vibrating contacts to be reversed. This considerably prolongs their life. The apparatus is suitable for use on machines up to a voltage of 500 and up to a maximum field current of 5 amperes. It may finally be noted that the regulator automatically controls the voltage of the dynamo during starting and will bring it to the normal working condition without the field rheostat being touched.

THE LATE SIR JOHN GAVEY, C.B.

WITH the death of Sir John Gavey, which occurred on Monday last, there passed away a man whose life's work was identified almost entirely with the development of telegraphy and telephony in this country. Long before the Government acquired the monopoly of the telegraphs, Mr. Gavey, as he then was, was working to extend and improve this means of communication, and when the transfer was effected he entered the service of the State, rising eventually to the highest technical position at the disposal of the Post Office. He was born at St. Helier's, in Jersey, on August 11, 1842, his father being Mr. John Gavey, a captain in the merchant service. His education was carried out at Victoria College, in the island of his birth, and then as a young man of eighteen he entered the service of the Electric and International Company on February 23, 1861, under Mr. (later Sir) William Preece. He soon showed evidence of ability, and by 1865 was acting as engineer-inspector of telegraphs in the south of England.

Sir John Gavey's career with the General Post Office commenced, as we have indicated above, in the year 1870, when the Government took over the telegraphs of the country. His first appointment in the Civil Service was on January 29 in that year, when he was given the position of Superintendent of Telegraphs in the South-Eastern Sub-Division. Two years later he was given a similar appointment in the Great Western Sub-Division, and on April 1, 1878, he was placed in independent charge of the South Wales District as Superintending Engineer. This position he filled until November 24, 1892, when he was transferred to the General Post Office headquarters as principal technical officer. In August, 1897, he was promoted to be Second Assistant Engineer-in-Chief, in February, 1899, a further promotion raised him to Assistant Engineer-in-Chief and Electrician, and on April 1, 1902, he attained the culminating position of Engineer-in-Chief and Electrician to the General Post Office. This he held until his retirement in April, 1907. In recognition of his services he was created a Commander of the Bath in 1902 and a knighthood was conferred upon him upon his retirement.

It is difficult to associate Sir John Gavey with any particular feature of telegraphic or telephonic work without incurring the risk of minimising his services in other directions. He was one of the early investigators of the problems involved in the use of automatic methods to increase the speed of working telegraph lines, and he also originated many improvements in underground cables with the same object in view. As early as 1894 he was taking an active interest in wireless methods of transmission, and in that year he succeeded in establishing communication between the opposite sides of Loch Ness by means of induction between two parallel wires stretched along the banks. The development of the telephone service also occupied much of his consideration, and in 1881 he opened the first telephone trunk line connecting two British towns, namely Newport and Cardiff. He was subsequently engaged in the task of valuing the telephone trunk lines which were purchased from the National Telephone Company by the Government, and later he was responsible for the organisation of a complete telephone trunk system for Great Britain. Another very important work carried out under his direction was the organisation of the Post Office telephone exchange system of London, the magnitude of the population to be served rendering the task one of a very special nature.

Sir John Gavey was one of the very early members of the Institution of Electrical Engineers, for he joined as an associate in 1872, the year after the body was founded, and when it was known as the Society of Telegraph Engineers. He appears to have been an active member, for in 1874 he read a paper on "Earth-boring for Telegraph Poles," before the society, the late Lord Kelvin, then Sir William Thomson, being in the chair. Subsequent papers from his pen were "Insulators for Aerial Telegraph Lines," in 1878, "The Telephone Trunk Line System in Great Britain," in 1896, and "Telegraphs and Telephones at the Paris Exhibition," 1900. He was elected to the Council of the Institution in 1899, became vice-president in 1903 and president in 1905. His presidential address delivered on November 9 of that year consisted of a review of telegraphic and telephonic progress, and a statement of the problems yet unsolved, which even to-day may be read with interest. Sir John's official position naturally caused him to take a prominent place in international and other events connected with his profession. He acted as Juror to the electrical section of the Paris Exhibition in 1900 and was a delegate to the International Electrical Congress in the same year. In 1903 he represented his department at the International Congress on Wireless Telegraphy at Berlin, and in 1906 he acted in a similar capacity at the Wireless Convention held in the same city. He was also a member of the British Committee for the St. Louis Exhibition in 1904. Sir John joined the Institution of Civil Engineers in 1899 and delivered the James Forrest Lecture before that Institution in 1910, his subject being "Recent Developments in Telegraphy and Telephony."

The subject of our memoir married in 1870, and one of his sons now holds an appointment in the Secretary's department at the General Post Office. Prior to Sir John's death he had been for some time in a very precarious condition, and he passed peacefully away at his residence in Hampton Wick on New Year's day. The funeral service will be held at 11 a.m. to-day at St. John's Church, Hampton Wick, and interment will take place at Teddington cemetery.

THE LATE MR. ALFRED EDWARD CAREY.

WE regret to have to announce the death, which occurred on December 30, of Mr. Alfred Edward Carey, the well-known harbour works engineer.

Mr. Carey was born in February, 1852, and was the son of the late Mr. Jonathan Carey, solicitor, Calcutta. He was educated at the Priory House School, Clapton, the City of London School and King's College. After serving a pupilage in the engineering offices of the London, Brighton and South Coast Railway, and with Messrs. Saxby and Farmer, he obtained, in 1874, an appointment as assistant engineer to the London, Brighton and South Coast Railway, where he had charge, under Mr. F. D. Banister, of the design and construction for the company of stores, gas works, permanent way, workshops and sawmills. In July, 1878, the Newhaven harbour and dock works were commenced, Mr. Banister being the engineer-in-chief. Mr. Carey was the resident engineer for these works until their completion, and he also designed the concrete-making machinery which formed one of the features of the work. In 1885 he was appointed engineer and managing director of the Sussex Portland Cement Works.

He commenced private practice in 1887, since when he acted as the engineer-in-chief of La Guaira harbour works. He further constructed five Portland cement plants at home and abroad, and acted also as engineer to the Hastings harbour works, the Coast Development Corporation, the Thames Haven Oil Wharves, Limited, and the Corporation of Southwold, for whom he carried out sea defence works and a harbour.

Mr. Carey was the author of "Newhaven Harbour Works," "Testing of Portland Cement," "Coast Erosion," "Tidal Lands," &c. He was senior partner in the firm of Carey and Latham, consulting engineers, 36, Victoria-street, S.W.1, responsible for the deep-water quay now under construction at Thames Haven, the recent marine extensions at Greenhithe for the Empire Paper Mills, Limited, the coast defence works for the county council of Somerset, and adviser to many companies and landowners on questions of coast defences and marine works, both in this country and abroad.

Mr. Carey was appointed a member of the Institution of Civil Engineers in 1884; he was also a member of various other scientific societies.

COAL IMPORT INTO DENMARK.—The import of coal and coke into Denmark in 1922 was considerably greater than in the previous year, says the *Danish Foreign Office Journal*. In the months January-October the import of coal amounted to 2,266,000 tons, against 1,600,000 tons in the corresponding period last year, and the import of coke and cinders to 643,000 tons against 328,000 tons. Practically the whole import in 1922 came from Great Britain, only 121 tons being imported from the United States of America last year against 188,000 tons the year before.

YEAR-BOOKS AND ANNUALS.

The Electrical Engineer's Year Book and Diary, 1923.—This year book hardly comes into competition with the ordinary type of pocket book and diary of which so many examples are published. It is the size of a business sheet of writing paper, and is, of course, intended as a desk diary. The size naturally allows a considerably more adequate space in the diary pages than is possible in any form of pocket book. The book is, however, by no means a mere diary, and contains a very large amount of technical and trade information on such subjects as the generation of electricity, the application of electricity for lighting, electric vehicles, &c. The information is collected in a very practical and usable form and shows careful preparation and original work. Copies of official electrical rules and regulations are also given, and a list of London streets in which electricity mains are laid, with the type of current, voltage and, where necessary, periodicity. This feature is likely to be of great value to many users. The volume is edited by Mr. J. H. Johnson, M.I.E.E., and is published by Messrs. S. Davis and Co., of 30 and 31, St. Swithin's-lane, E.C. 4, at 21*s.* post free.

The Business Directory, 1923.—The sixty-first annual edition of this directory is notable for important changes in the size, arrangement and contents of the volume. All the special features of the earlier editions are retained, but the value of the work has been increased by the provision of a column for the cable addresses and telephone numbers of every firm listed in the London alphabetical section. The entries in this column, which will relate to about 100,000 firms, are hardly complete, but this is to be remedied by next year. The directory, which is published by the executor of J. S. C. Morris, at 52, Holborn Viaduct, London, E.C. 1, comprises nearly 2,000 pages and contains about 300,000 entries relating to commercial firms in the United Kingdom. In spite of its magnitude it is very easy to use on account of the simplicity of its arrangement. It is divided into two sections. The first covers 724 pages and consists of an alphabetical list of London and suburban firms, together with their businesses and addresses, while the second section comprises the principal London and provincial firms classified in accordance with their businesses. In this section a good many foreign firms are also listed. The volume, the price of which is 2*l.* net, has a striking appearance owing to the rich blue colour of its binding.

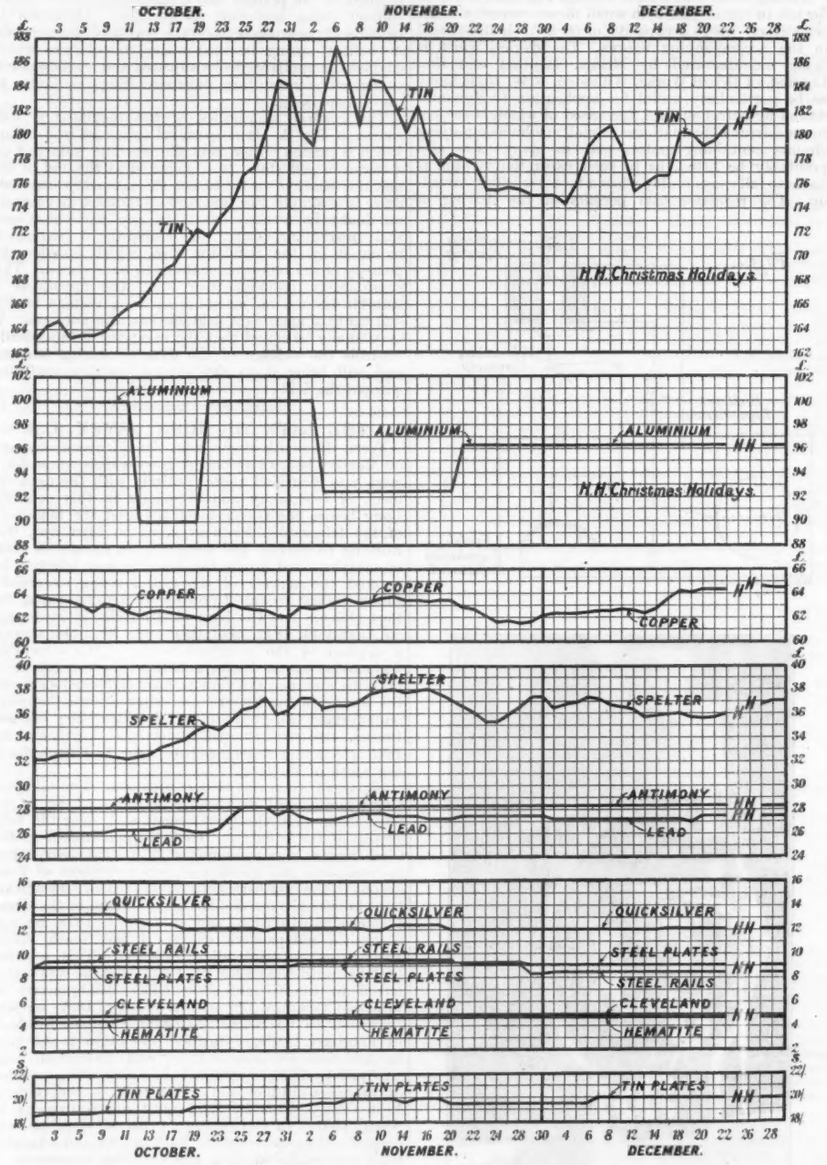
The Textile Recorder Year Book, 1923.—Compiled and edited by Frank Nasmith, editor *Textile Recorder*: John Heywood, Limited, 121, Deansgate, Manchester, and 20 to 22, St. Bride-street, E.C. 2 (price 7*s.* 6*d.* net). This year book styles itself "a textile library in brief," a title which we find fully justified. It deals with cotton, hosiery manufacture, woollen and worsted, flax, jute and ramie, silk, both natural and artificial, starting from the raw material and following up every process of manufacture to the finished articles. We are glad to find confirmation in the chapter dealing with cotton dyeing that very many dye-stuffs previously imported from Germany are now made in this country, also that almost all the foreign-made sulphur dyes can now be satisfactorily matched. A section of special technical interest has reference to the testing of yarn. The book is a complete compendium of a British staple industry, reference to which is greatly facilitated by a very detailed index. It will prove of great value not only to manufacturers and traders in the textile industry, but also to general engineers and merchants who may frequently be called upon to consider questions connected with the manufacture and the sale of textiles.

Diaries.—We have received a copy of the "Surveyors' Tables and Diary," Metchim and Son, 8, Princes-street, S.W. 1. This pocket diary contains a large amount of information in house building, structural work, &c., leases, also conversion tables. The diary portion takes up a page per week. Mr. J. Martin Blair, Amberley House, Norfolk-street, Strand, W.C. 2, representing Hengelosche Electrische en Mechanische Apparaten-Fabrick, Hengelo, Holland, has sent us a diary of this firm.

Almanacks and Calendars.—Daily tear-off calendars have reached us from the English Electric Company, Limited, Queen's House, Kingsway, W.C. 2; Messrs. Thomas Robinson and Son, Limited, Railway Works, Rochdale; Milner Hurd's Patents Company, Limited, 4, Paradise-square, Sheffield. We have received monthly tear-off calendars from Messrs. George Cradock and Co., Limited, wire rope works, Wakefield; Messrs. William Firth, Limited, iron and steel merchants, Leeds; the Submarine Signal Company, Friars House, New Broad-street, E.C.; Messrs. John I. Thornycroft, Limited, Southampton, Basingstoke, and Thornycroft House, Smith-square, S.W. 1. Desk calendars from Messrs. Brook, Hirst and Co., Limited, electric switchgear manufacturers, Northgate Electrical Works, Chester, London and Glasgow, who for many years have identified the name "Brookhirst" switch gear with their manufactures; they announce that they have decided at an early date to carry on their business under the company title of "Brookhirst Switchgear, Limited." A desk calendar also comes from Messrs. J. Evershed and Co., printers, Fairfield-road, Bow, E.3. Monthly tear-off calendars have further reached us from the D. P. Battery Company, Limited, Bakewell, Derbyshire; the Brightside Foundry and Engineering Company, Limited, Sheffield; Messrs. W. H. Wilcox and Co., Limited, engineers' stores, 38, Southwark-street, S.E.1; Messrs. Hollings and Guest, Limited, engineers, Thimble Mill-lane, Birmingham; Messrs. J. C. Fish, Hall and Co., manufacturing stationers and printers, 11, Bishop's-court, Chancery-lane, W.C.2; Messrs. Haslam and Stretton (Engineering and Motor Utility) Company, Cardiff, Bristol and Swansea; we have also received a wall-calendar from Messrs. C. Isler and Co., Limited, artesian well engineers, Bear-lane, Southwark-street, S.E. 1.

DIAGRAMS OF THREE MONTHS' FLUCTUATIONS IN THE PRICES OF METALS.

(Specially Compiled from Official Reports of London Metal Markets.)



NOTE.—In the diagrams the figures plotted for tin and copper are the official closing cash quotations of the London Metal Exchange for fine "foreign" and "standard" metal respectively. The prices shown for lead are for English metal, whilst those for spelter are for American metal. Middlesbrough prices are plotted for steel plates and rails, and also for hematite and Cleveland pig-iron. The prices given in the case of steel plates are for ship, bridge and tank qualities, and those for steel rails are for heavy sections. The pig-iron prices are for the East Coast hematite and Cleveland iron, both of No. 1 quality and for home consumption. The price of tin-plates is per box of I.C. cokes f.o.b. at Welsh ports, but in all other cases the prices are per ton. Each vertical line in the diagram represents a market-day, and the horizontal lines represent 1*l.* each, except in the case of the diagram relating to tin-plates, where they represent 1*s.* each.

WATER POWER IN ESTHONIA: CORRECTION.—Our paragraph on Water Power in Esthonia, on page 803 of last week's issue, contained a historical reference to the battle of Narva, 1700, in which the names were misplaced. Charles XII. of Sweden, defeated the Russians in the battle referred to.

REFINERY AND ROLLING MILL FOR MONEL METAL.

A PAPER read before the annual meeting of the American Institute of Mechanical Engineers, which was held from December 4 to 7 at New York, described in detail the steps taken to select a location for a works to produce and roll monel metal. In this paper, Mr. W. L. Wotherspoon not only discussed the economic problems involved in the question of site selection, but also the lay-out of the plant. In the following we give the main features of the paper largely in the form of an abstract.

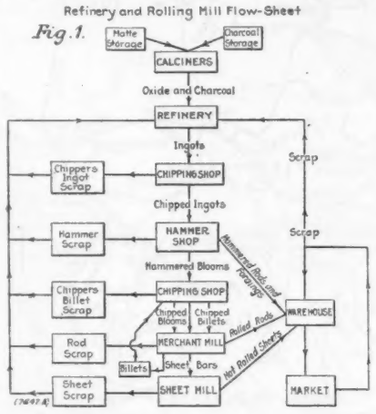
The substance known as monel metal is a natural alloy, and consists of 67 per cent. nickel, 28 per cent. copper, and a mixture of other elements making up the remaining 5 per cent. It has the appearance of nickel but in tensile strength is comparable with steel, while it has a high resistance to corrosion and can be cut, rolled, welded, machined and forged. The metal is produced in the refinery from monel-metal bessemer matte and is worked to produce merchant bars, forgings, wire and sheets. To provide for the increased production necessary to meet the demand for this material, the International Nickel Company has recently completed a refinery and rolling mill at Huntington, West Virginia, U.S.A. Before deciding the geographical position of these works a general survey of the requirements to be met was made by the engineers and management of the company. This consideration involved the discussion of the past volume of business, the estimate of the potential markets, and the minimum amount of plant necessary to meet present demands and those probable in the immediate future. For the complete understanding of the problem of the nature and size of plant for such a scheme as this, a flow sheet for the operations proves of great service. Fig. 1 gives the flow sheet in question, and shows clearly the relationship of all the different operations involved in the process.

The general plan of the works (Fig. 2) shows how the lay-out has been effected after due consideration of the information given in the flow sheet. The size and the location of the individual units in the works were determined solely on the basis of proportional output of the sections and the sequence of the various operations. As a result of this survey Mr. Wotherspoon reached the following conclusions: The existing and prospective business for monel metal justified the estimated capital expenditure of approximately 3,000,000 dols. for a rolling mill to produce rods and sheets, and that the existing markets for monel metal and other alloys were such that the plant should be laid out with provision for considerable expansion. Natural gas, being practically free from sulphur, was the ideal fuel for the heating purposes. Should it be necessary to utilise producer gas, the estimated capital expenditure for plant and equipment would be increased by approximately 200,000 dols. The particular disposition and service of the merchant and sheet mills was such that individual electric drive, with gear reductions where necessary, would suit the conditions best. Purchased electric power was to be preferred, and if not available the capital expenditure would be increased by approximately 750,000 dols. A site of at least twenty, and preferably up to fifty, acres was thought necessary.

After this survey of the requirements, and when the conclusions were available, a careful consideration of the merits of the following districts for the site of the works was undertaken: Bayonne, N.J., Buffalo, N.Y., Baltimore, Md., Pittsburgh, Pa., and Huntington, W.Va. Although the ores and bessemer matte from which monel metal is produced come from the International Nickel Company's mines and smelting works in the Sudbury District of Ontario, Canada, and a new refinery for nickel products had been constructed a few years ago at Port Colborne, Ontario, Canada, economic factors, such as tariffs, fuel, markets for finished products, &c., were such as to limit the detailed study of locations for the new works to the eastern parts of the United States. The territory and principal railways which serve customers, and prospective markets for the products of the works, are shown in Fig. 3, page 26. This area covers the largest manufacturing districts of the United States, with Chicago and St. Louis in the West, and New York and Philadelphia in the East, and Huntington, it will be noticed, is centrally situated in this territory and is in close proximity to the districts where coal, oil and natural gas are obtained. Bayonne, N.J., was considered, as the company had a large refinery there and it was thought the rolling mill might be an addition to the existing works. After the investigation, however, the Bayonne refinery was closed down and the plant dismantled, leaving available an excellent site on New York Harbour for some other industry for which the economic conditions are suitable.

Refinery and Rolling Mill Flow-Sheet

Fig. 1.



A schedule is given in the next column of the factors investigated before finally deciding on the site.

After consideration upon this basis, the figures shown in the following table were deduced to show the percentage value of each item for each location, taking the marks given in the highest case as 100.

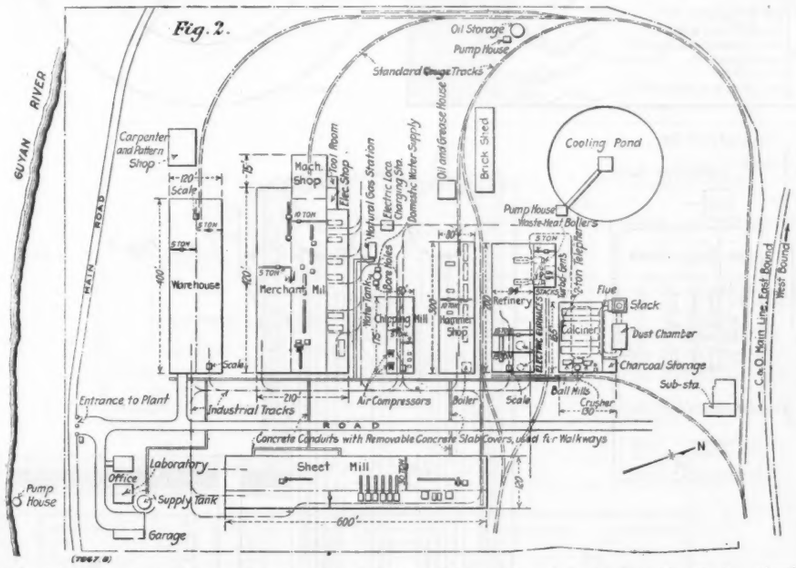
Locations.

—	Huntington.	A.	B.	C.	D.
Labour	100	90	82	75	65
Fuels	100	55	50	60	55
Power	100	90	95	90	60
Living conditions ..	100	90	90	85	80
Transportation	100	95	90	90	90
Water	100	90	75	85	15
Climate	100	90	85	90	85
Supplies	100	90	90	95	85
Taxes and laws	100	100	100	90	80
Site (cost and quality) ..	100	75	50	50	30
Construction cost ..	100	90	80	80	70

Fig. 4 shows the connections to thirteen important railways within 175 miles of Huntington. The Ohio River is navigable all the year, and there is a regular service of boats between Pittsburgh, Huntington and Cincinnati. The advantages which this district possesses for the purpose of the refinery and rolling mills are very marked. The workers, both common and skilled, available are 95 per cent. English-speaking Americans and have good records for steadiness and industry in many types of work, and the majority of them own their homes. A plentiful supply of natural gas with a calorific value of 1,100 British thermal units per cubic foot, is available from companies in the district at a cost of from 18 to 19 cents per 1,000 cub. ft. The indications are that a supply of such gas will be available for fifteen to twenty years. A local oil refinery provides a good supply of high grade oil with a low sulphur content, at a price, at present, of 5 cents to 6 cents per gallon, delivered at the plant. High grade bituminous steam and gas coal can be obtained from the local coal field at a cost of 2·50 dols. to 3·00 dols. per ton, delivered at the works. Two modern central stations at Huntington supply power to large consumers at a cost of 1·1 cents to 1·2 cents per kilowatt-hour. River water is available, and borings show a good supply at an average depth of 60 ft. The climate is equable, with cool nights and little snowfall. Refractory materials, charcoal, castings and steel can all be obtained in the district. There are no smoke laws at all in West Virginia. A site of 76 acres was procured just outside the present city boundaries of Huntington, having a direct connection with the Chesapeake and Ohio Railway. When the extensions at present planned are completed, a similar siding on the Balitmore and Ohio Railway is contemplated. The Guyan River which is beside the works, as is seen in Fig. 2, joins the Ohio River about one mile further down its course. Flood conditions were investigated and it was found that only on two occasions during the last forty years had floods been so high as to endanger to even a small extent any property at the elevation of the selected site. The ground is excellent, being composed of solid clay for a depth of 12 ft. to 18 ft. under which there is a stratum of compact coarse sand.

The matte received from the company's smelting works in Canada, in irregular pieces weighing about half a hundredweight, is unloaded from the railway wagons and passed through a 24-in. by 16-in. jaw crusher and reduced to general dimensions of about 1½ in., and is then fed into Krupp-type ball mills where it is further reduced to pass through a 16-mesh. The crusher and mill plant can deal with 45 tons in an eight-hour day, and with a storage bin for the matte having seven days' capacity, the plant can be used intermittently to suit convenience or the arrival of consignments of the raw material. This plant, and the conveyor connecting its two parts, is belt-driven through a line shaft by a 125 h.p. 3-phase squirrel cage motor running at 900 r.p.m. Two large flywheels are fitted to the crusher and a controlled feed system to the ball mills to ensure regular working. The ground matte is fed mechanically into

Fig. 2.



Schedule of Factors Investigated.

- Labour ... ... Skilled / Common ... Type, Supply, Rates, Strikes
- Fuels: Metallurgical / Power Generation — Cost and Quality — Oil, Producer gas, Natural gas, Coal, Coke
- Power ... Public Service Electric Supply ... Costs, Service
- Living Conditions: Housing, Cost of Living, Sanitation and Health
- Climate ... ... Minimum and Maximum Average Temperatures, Average Snowfall, Average Rainfall
- Transportation: Railroads / Water
  - Sources and Costs of Supplies: Matte, Refractories, Rolls, Castings and Mill Spares, Sheet Bars, Charcoal, Electrodes, Chemical and Metallurgical — miscellaneous supplies, Lubricating Oils, General Stores
  - Products, Distribution of: Monel and Monel Shot, Pig, Sheet Rod, Wire Rod, Forging — Domestic / Export
- Water Supply ... ... Service, Costs, Quality
- Taxes and Laws ... ... State, Local
- Selection of Site: Railroad Connections, Character of Ground for Building and Equipment Foundations, Drainage and Flood Conditions, Accessibility for Labour, Grading and Facilities for Slag Disposal, Provision for Expansion of Works
- Construction Costs ... ... Labour, Material, Supplies

The marks assigned to each factor were:—

Labour	250
Fuels	330
Power	100
Living conditions	100
Transportation	50
Water supply	10
Climate	50
Supplies	60
Taxes and laws	20
Site (cost and quality)	10
Construction cost	20

the roasting furnaces, of which there are three. Electric travelling hoists of the monorail type and of 2-ton capacity carry the material from the bins to the furnaces. The telpher has a lift of 30 ft., a hoisting speed of 20 ft. to 50 ft. per minute, a travelling speed of 300 ft. to 350 ft. per minute and operates on a 12-in. I-beam connected directly to the lower chords of the roof trusses. The roasting furnaces are of the horizontal type, 80 ft. long and 17 ft. wide, the material being moved along the hearth by rubbles operated by a mechanical chain and gear transmission mounted over each furnace. The rubbles have monel metal shoes and are made hollow to permit of water cooling. Natural gas is used as fuel for these furnaces which each have a capacity of 25,000 lb. for a 24-hour day. The roasted matte is discharged by gravity into large buckets and ground charcoal is mixed with the hot material so that its reduction is started at the time it leaves the furnace. The charcoal is procured locally in irregular sticks and is broken in a rotary type of crusher. This material, after crushing, is stored in a bin, but only in comparatively small quantities because of the dangers of spontaneous combustion. The bin is of fireproof construction and subdivided to reduce the hazard. The cooling water from the rubbles, about 100 gallons per minute, which is raised in temperature to 160 deg. F., is taken to the boiler-feed tank.

The refinery is situated beside the crushing and calcining plant (see Fig. 2) and contains two open-hearth furnaces of 35,000 lb. per day capacity, arranged for firing by natural gas or oil (Fig. 5). The roasted monel-metal oxide and the ground charcoal are delivered by the monorail trolley hoisting system. Refractory material of a very high grade is used in the construction of the furnaces owing to the high temperatures to which they are subjected, the tapping temperature being about 2,800 deg. F. As the heat utilised in this type of furnace does not exceed about 15 per cent. of that available from the fuel, a 600 h.p. boiler of the waste-heat type provided with a superheater is installed behind each furnace. Steam generated from this plant is used by the hammers and in the auxiliary power-house, which is an extension of the refinery and contains two 750 kw. turbo-alternators. These boilers were reconstructed from boilers of the 4-drum type formerly used at the Bayonne Refinery (Fig. 6). The power generated, it is anticipated, will cost 0·4 cent per kilowatt-hour.

Fig. 3. MAP SHOWING RAILROAD AND MAJOR INDUSTRIAL PORTION OF THE UNITED STATES

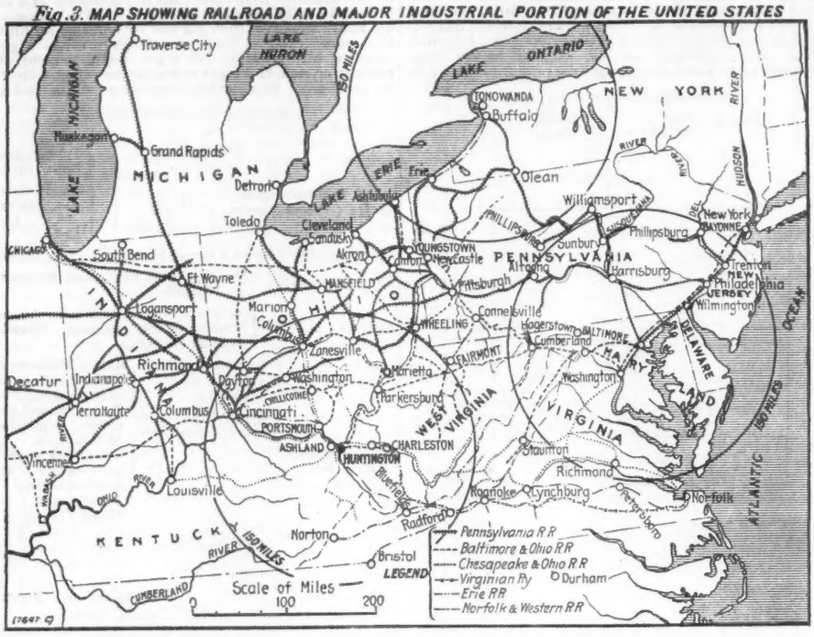
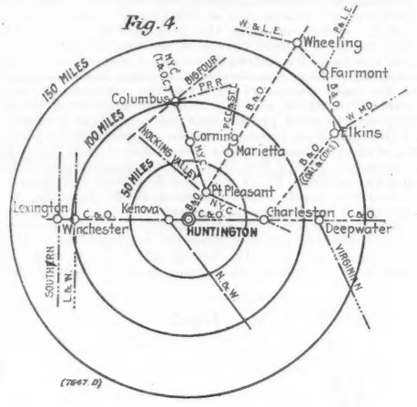


Fig. 4.



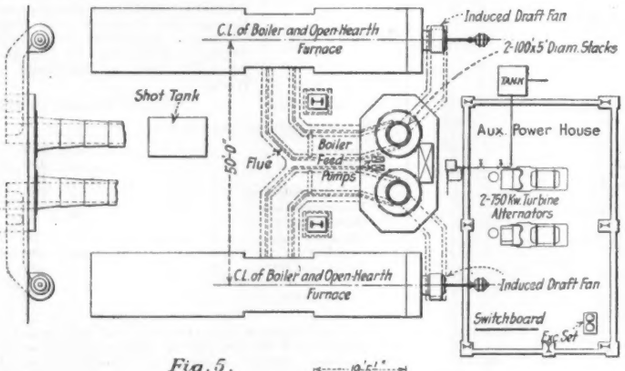


Fig. 5.

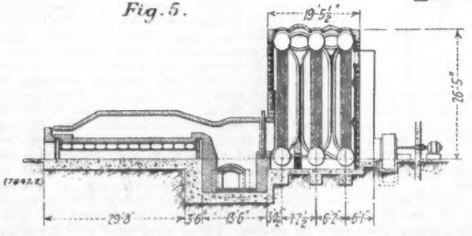
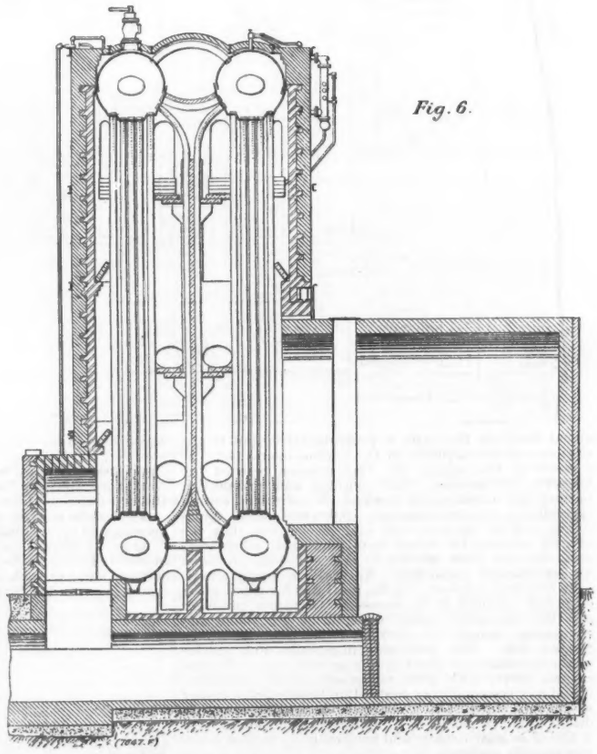


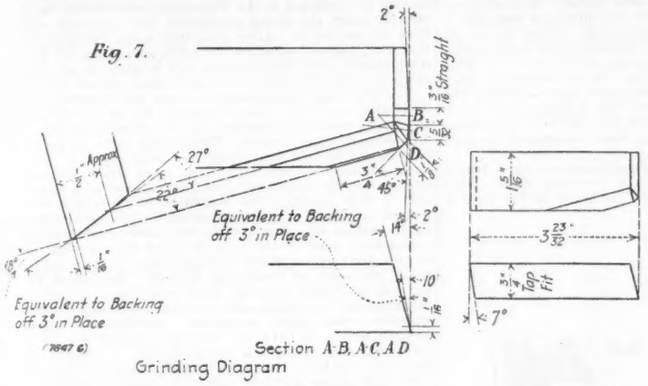
Fig. 6.



At the side of each furnace there are water tanks into which the monel metal can be directed from a movable spout to produce shot. Electric furnaces of the Moore and Heroult type, with charge capacities of 3 tons and 7 tons respectively, are installed side by side in the other end of the refinery. The charge floor is made of reinforced concrete and is 12 ft. above the main floor, 100 ft. long and 35 ft. wide. The furnaces are basic-lined and the elimination of sulphur and oxygen is carried on under basic slag. The moulding bay is served by two 15-ton travelling cranes. Monel metal ingots are produced directly from either the open-hearth or the electric furnaces. Pig metal produced in the open-hearth furnaces, together with scrap, is used as the charge for the electric plant. The power consumption in the electric process varies from 642 kw. to 714 kw.-hours for every ton of melted monel metal.

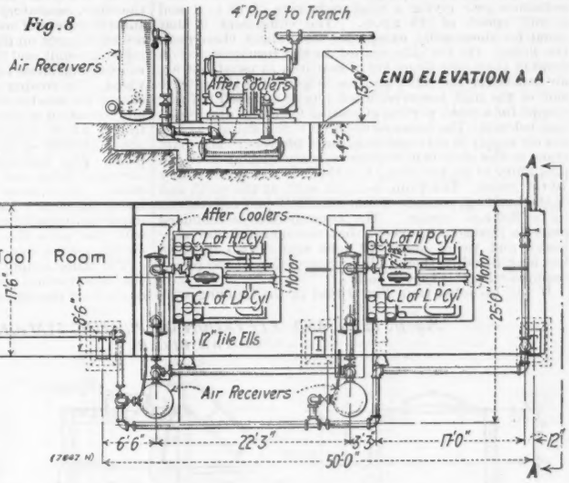
To ensure a uniform hammered or rolled product the outer skin of the monel-metal ingots is removed. This was previously done by pneumatic chipping, but milling is now replacing this practice. The ingot is placed on the table of the machine which is fitted with four points of hardened steel, one fixed, one adjustable, and two mounted on a rocker arm so that the ingot can be quickly trued up by the manipulation of the adjustable point. Two set screws are mounted on the bottom clamp casting for squaring the ingot with the table. To turn the ingot a steel tower has been erected on one side of each machine supporting two chain slings so that, with the table at the extreme traverse, the chains are placed one round each end of the ingot and the table lowered. The operator can then with a bar easily turn the ingot 90 deg. for the new set-up. To overcome the tendency for the tapered ingot to slip longitudinally while being milled, and to eliminate the time wasted by the operator in tightening and loosening the bolts, together with the risk of damage to the milling cutters, a pneumatic clamp is now being designed which will decrease considerably the clamping and reclamping time. Approximately 250 lb. of metal are milled from the large ingot in the actual cutting time of 2 hours 40 minutes. The total time to finish the ingot, including resetting of tools, turning and reclamping of ingots is 4 hours, 13 operations being required. The plant used consists of 8-in. mills of special design with extra heavy steel bodies, case-hardened chip breakers, and 10 inserted 1½-in. by ⅜-in. high-speed steel blades. The blades are set in the body

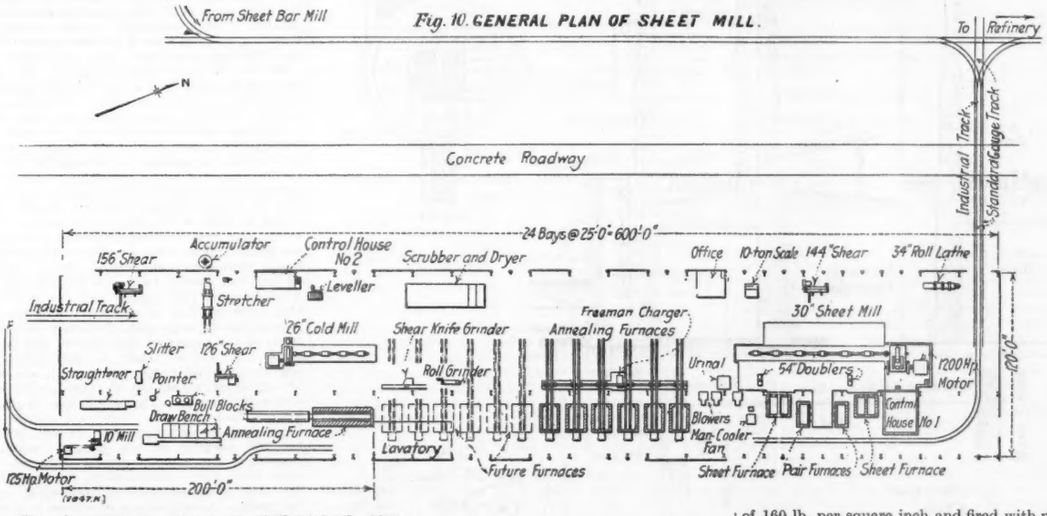
so that the rake angle which the face of blade makes with a radial line is 15 deg. Cutters of special design are used to mill the corners of the ingots, and are mounted on a quick-change extension shank to allow for quick setting without removal of the face mill. The face mill is run at 16 r.p.m., taking ¼-in. depth of cut with feeds of 4½ in. and 4⅝ in. per min. The angular cutters are run at 38 r.p.m. and a feed of 5⅛ in. per minute. A considerable amount of test work has been performed to determine the cutter clearance angles necessary, and as a result of this, the practice adopted is shown in Fig. 7. High-speed steel blades hardened and drawn at 1,150 deg. F. have consistently cut eight ingots with the

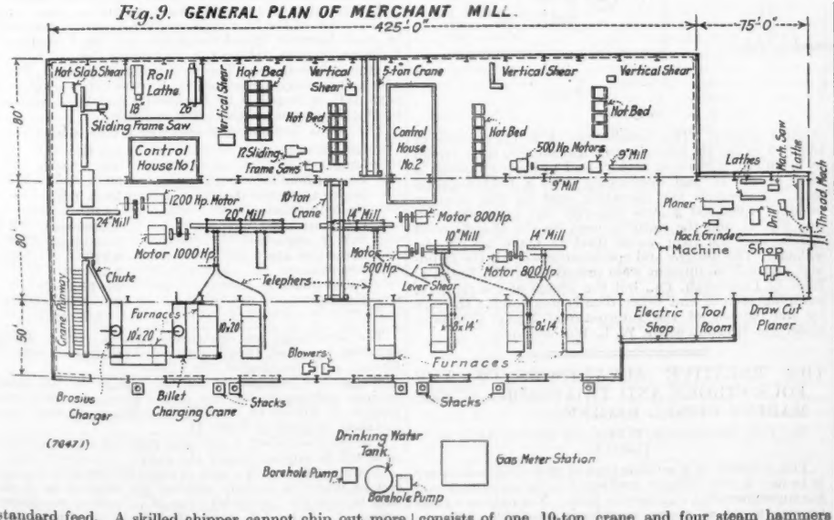


supplied from two electrically-driven horizontal air compressors which are placed in a corner of the chipping shop, after coolers are installed, because of the importance of having cool, dry air for the pneumatic tools. Fig. 8 illustrates the general arrangement of the air-compressor plant. Each of the two compressors will deliver 1,030 cub. ft. of air per minute at 100 lb. gauge pressure and is driven by a 210-h.p. synchronous motor running at 250 r.p.m.

After chipping, the ingots are taken to the hammer shop. The equipment here







standard feed. A skilled chipper cannot chip out more than 1,200 sq. in. to 1,500 sq. in. in an eight-hours' shift or approximately two sides of a 2-ton monel-metal ingot. The milling machines have a capacity of one ingot every four hours. Any defects not removed by milling are chipped away.

Compressed air for the chipping and other work is consists of one 10-ton crane and four steam hammers of 16,000 lb., 10,000 lb., 3,500 lb., and 1,500 lb. capacity respectively, and the necessary handling gear. The heating furnaces, five in number, are of the Steven's regenerative type, four with hearths 7 ft. by 20 ft. and one with dimensions of 7 ft. and 14 ft. They are all equipped with hand-control gear and with automatic air and gas regulating fittings. Two steel-plate blowers supply air to the heating furnaces at a pressure of 1 lb. per square inch gauge. The blowers are each of 7,200 cub. ft. per minute capacity, and one driven by 50-h.p. direct-current motors with variable speed control, providing a range of from 1,000 r.p.m. to 1,700 r.p.m. Two Stirling boilers, operating at a pressure of 160 lb. per square inch and fired with natural gas, are installed in the hammer shop, but under normal conditions of running the steam for the hammers is obtained from the waste-heat boilers in the refinery. The two heavy hammers are used for cogging or breaking down and have been found more suitable for this work than the usual mill or hydraulic press. These hammers are of the double-frame type and built of steel throughout. The frames are held together at the bottom by a cast-steel base plate. The ratio of anvil weight to the falling weight is 15 to 1. Cushioned safety-cylinder covers are used in these hammers and special guides and shoes.

The rolling mills are divided into two departments, the first for the production of bars, billets, rods and wire, and the second for the manufacture of sheets, both hot and cold rolled. On account of the extremely tough character of monel metal and the tendency it has of cooling rapidly, it is necessary to have mills of great strength and rigidity. The type of material rolled is similar to alloy tool steel and it is very necessary to have mills in which the machine work and general finish are the best obtainable. The hammered ingot or bloom, after being overhauled to remove any scale or surface imperfections, is delivered to the 24-in. sheet-bar mill, located in the merchant-mill building. This mill consists of two stands, the first stand three-high and the bullhead or finishing stand, two-high. The handling of blooms to the heating furnaces and thence to the standard mill tables is by means of a Brosius charger. The tilting tables, which are 25 ft. long, the transfer, and the other table operations are controlled from the same platform. After being rolled the bar is carried to a powerful shearing machine capable of cutting 3½-in. by 12-in. billets.

The general arrangement of the sheet mills is shown in Fig. 10. The mills themselves are exceptionally heavy, the roll diameters being 30 in. and the maximum sheet width 48 in. The present equipment consists of two finishing mills and two roughing mills, each finishing mill having a roughing mill of its own. The roughing rolls are balanced and are driven by fully enclosed cut

gears, rather a new development in sheet-mill practice, giving a very smooth movement and reducing the tendency of the pinion teeth to mark the sheet. A specially-designed drag, known as the "Conklin" is fitted. The roughing rolls are screwed up and down by a motor drive, for which a 40-h.p. motor is used carried on the top of the pinion housing. The main motor to drive this mill is a 1,200-h.p. motor, provided with a double-reduction gear giving a total reduction of 13 to 1 and a mill speed of 26 r.p.m. The equipment is that usual for sheet mills, except for some slight changes in the floors. On the side nearest to the furnaces and in front of them, the floors are of cast-iron as usual, but are air cooled for the roller and his helper. On the catcher side of the mill, however, wood blocks are used entirely except for a small portion of grating floor with air circulating below it. The furnaces are fired with natural gas and the air supply is obtained from large blowers. The main crane in this shop is of 30 tons capacity with an overload possibility of 25 per cent., but there is also an auxiliary 10-ton crane. The 26-in. cold-roll mill, at the south end of the building, consists of four stands of cold rolls driven by a 300-h.p. motor. The construction is standard practice throughout, except that the housings are very heavy and weigh about 12 tons each. No flywheel has been fitted as there is little fluctuation in the power required with this type of mill.

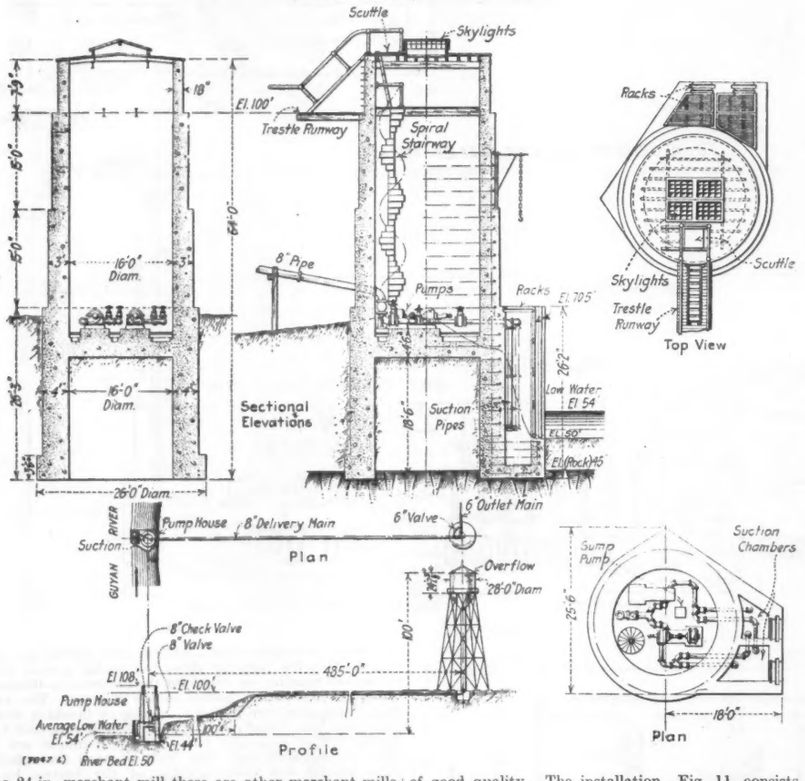
It will be noted from Fig. 9 that in the building with the 24-in. merchant mill there are other merchant mills used for furnishing the greatly varied products of the company. This equipment consists of the 24-in. mill referred to previously, which not only makes sheet bar but also the various sizes of billets required, a 20-in. mill, a 14-in. mill, a 10-in. mill, and a 14-in. Belgian rougher; and the wire mill, which consists of two separate mills in line with each other, one being a five-stand roughing mill and the other a four-stand finishing mill. These mills are equipped with, gears and direct-motor drive, and each has a flywheel on the motor-shaft except the 9-in. roughing mill, which, due to construction difficulties, has the flywheel on the mill-shaft. The 9-in. finishing mill drives direct without any flywheel or gear reduction. With the exception of the two 9-in. finishing mills, the mills are what might be called slow-speed mills, as, in spite of the fact that the material cools quickly, it is not advisable to roll it too fast, and this had to be given special consideration in deciding upon the speeds to employ. All mills are driven by fixed-speed motors except the 10-in. mill, which requires a variation from 120 r.p.m. to about 80 r.p.m. to accommodate the varied size of material, and the 9-in. mill, the intermediate between the 14-in. roughing and 9-in. finishing mill, which has a speed variation of 257 r.p.m. to 384 r.p.m., arranged in 17 intermediate steps, to accommodate the delivery speeds of the 14-in. mill.

The whole of the south side of this building is arranged with lifting doors, so that it is easy to adapt the temperature of this end to either summer or winter conditions, the same type of doors being arranged at intervals on the furnace side. Lubrication of mill reduction gears and pinions was given much study, and a combined pressure and gravity system was installed in the control houses. Small plunger pumps are considered preferable for this service, as with their use there is no tendency to form an emulsion as is the case with some pumps of the rotary type.

The dimensions and arrangements of the buildings are shown in Fig. 2. All the buildings, with the exception of the office, laboratory, oil and grease house and the electric substation, are of steel construction. Steel lifting doors are continuous on the sides of the refinery, hammer shop, merchant-mill and sheet-mill buildings, and for truck or railroad entrances to buildings rolling steel doors are provided. The roofing and sheeting is of corrugated black sheets, the windows have wooden sashes, which take up any variation in the steelwork and eliminate warping of frames which otherwise might occur. There are in all about 160,000 sq. ft. of these windows used in the entire plant. The buildings were given two coats of a non-corrosive paint and a finishing coat of battleship gray colour, which gives a pleasing appearance and aids the inside lighting. Reference to Fig. 2 shows that every important department is served with railway connections with the main line and that there is suitable storage facility for the wagons.

The water supply was obtained from bore holes during the construction and until the pumping station was erected on the Guyan River. The water of the river is of good quality. The installation, Fig. 11, consists of two 500-gallon De Laval centrifugal pumps, each driven by a 40-h.p. 2,200-volt motor, and operating against a head of 210 ft. and discharging into a 150,000-gallon tank. To reduce the operating load on this plant a pond of 4,000,000 gallons capacity has been provided (see Fig. 2), and the water is used on the closed-circuit system and the river water used to make up for the leakage. The designs and specifications of all the buildings and mill equipment were prepared by Mr. Frank I. Ellis, of Pittsburgh, Pa., but the design of the refinery, pumping station and other details was carried through by the officials of the International Nickel Company under the direction of Mr. W. L. Wotherspoon.

Fig. 11. PLAN AND ELEVATION OF PUMPING STATION (GUYAN RIVER)



THE RELATIVE ADVANTAGES OF THE FOUR-STROKE AND TWO-STROKE CYCLE MARINE DIESEL ENGINE.*

By A. S. WATKINSON, B.Eng. (Liverpool), Assoc.M. Inst.C.E.

THE question of a suitable type of propelling machinery is to-day a very difficult problem for the shipowner and his superintendent engineer to face. Not only are there several types of steam machinery available, but the internal-combustion engine has made such rapid strides in the last few years that no shipowner contemplating the building of new tonnage can afford to neglect giving it his most serious consideration. Of the ships building in this country to-day, over 6 per cent. are motorships, and in Denmark and Sweden the proportion of motorships to the total number of ships under construction is 60 per cent. and 53 per cent. respectively. It is also significant that of the large number of inquiries which shipbuilders have received this year, the majority are for ships propelled by Diesel engines.

Having decided to adopt internal-combustion machinery for his new ship, the shipowner has next to select the most suitable type of engine for his purpose. From the shipowner's point of view, undoubtedly the first and all-important consideration is reliability, both in operation at sea on long voyages and in manœuvring. If an engine cannot be designed to be thoroughly reliable for long periods under the above conditions, the shipowner will have no use for it. After reliability come questions of first cost, weight and space occupied, cost of repairs and maintenance, fuel consumption and lubricating oil consumption, and the ability to burn inferior grades of fuel.

The first large Diesel-engined ships, the Selandia, the Jutlandia, and the King Christian X, were built in 1912, and were soon followed by the Annam, the Siam, and several other vessels. These ships were propelled by the well-known Burmeister and Wain type of four-cycle engines, and are still doing good service at sea. During the war, motorship construction was at a standstill in this country, but considerable experience was gained in Diesel engine construction for submarines, small tenders, &c. Many of the two-stroke cycle engines constructed were of the type in which the scavenge air is admitted to the cylinder through valves in the cylinder head, and most of these were failures. Meanwhile the pre-war four-cycle engined ships continued to operate satisfactorily throughout the war, and it is small wonder, therefore, that when motorship development again became active, in 1919, the four-cycle engine should be favoured, and by far the larger number of ships built since the war have been fitted with engines of this type. Two-cycle engine builders have to live down the failure of the early engines of this type, but this engine is certainly gaining ground, especially in this country, and it is interesting to note that a greater number of British firms are building two-cycle than four-cycle engines.

It will be convenient to divide the advantages and disadvantages of four-cycle and two-cycle engines under two main headings, namely, "Fundamental considerations" and "Mechanical and structural considerations."

Fundamental Considerations.—In each cylinder of a two-cycle engine there is a working stroke for every revolution, as against a working stroke in every two revolutions in a four-cycle engine cylinder, and it would appear at first sight that for cylinders of equal dimensions the two-cycle engine cylinder would give twice the power of that of the four-cycle engine. This, however, is not the case, for the following reasons:—The piston speeds are, on an average, about 10 per cent. less, and the brake mean effective pressures are, on an average, about 4½ per cent. less in two-cycle than in four-cycle engines. Thus in four-cycle engines and two-cycle engines having the same number of cylinders and the same cylinder dimensions in each case, the latter will develop 171 per cent. of the power of the former, this being an average figure. It follows that in four-cycle and two-cycle engines of equal power the weight, size and cost of the two-cycle engine should be considerably less than of the four-cycle engine. This advantage is partly discounted by the fact that the two-cycle engine requires to be fitted with scavenge pumps. It will, however, be better for the purpose of the present paper, especially as engines of the same power by different makers of each type vary very considerably, to examine the weights and sizes of actual engines from which comparisons can be made. A comparison of several is given in Table I.

As the Burmeister and Wain engine is the most widely used of the four-cycle engines, a comparison will be made between it and the Sulzer and the Camellaird-Fullagar engines, taking the motorship Peru as a basis for the calculations. The twin-screw motorship Peru, which was fully described in ENGINEERING (Vol. cii, page 324), is propelled by Burmeister and Wain engines, having the characteristics given in Table I.

The main dimensions of this ship are as follows:—

Length over all	442 ft.
Length b.p.	425 ft. 5½ in.
Beam (moulded)	55 ft.
Depth to shelter deck ...	38 ft. 6 in.
Draught (loaded)	28 ft.
Displacement	13,400 tons
D.W.T. capacity	9,400 tons
Gross tonnage	6,919
Net tonnage	5,223
Speed (loaded)	11·15 knots
Engines	2 × 1,250 s.h.p. at 125 r.p.m.

The auxiliaries are electrically driven, current being supplied by three Diesel engine-driven dynamo sets of 60 kw., each running at 300 r.p.m.

Weight.—A comparison of the weight of the main engines and generating sets of the above ship with the weights if Sulzer or Camellaird-Fullagar engines were installed, is given in Table II.

The other auxiliary machinery need not be considered, as it will be approximately the same in all three cases.

A comparison on the basis of equal deadweight tonnage can be made by slightly altering the dimensions of the ship to suit the particular type of propelling machinery proposed. Table III. shows the alterations which might be made to the design of the ship in each case, and the advantages accruing. Figures for two alternative designs of ship are given for the Sulzer and the Camellaird-Fullager engines. In the first alternative in each case the beam, depth and draught are reduced, the length and the block coefficient remaining the same as in the

* Abstract of a paper read before the Liverpool Engineering Society, November 29, 1922.

TABLE I.—PARTICULARS OF ENGINES OF 1,250 B.H.P.

Engine.	Two-cycle or Four-cycle.	B.H.P.	No. of Cylinders.	Bore.	Stroke.	R.P.M.	B.M.E.P.	Piston Speed.	Weight.	Overall Length.
				ins.	ins.		lbs. sq. in.	ft.-min.	Tons.	ft. ins.
Burmeister and Wain ..	4	1,250	6	24·8	37·8	125	72	785	192	37 6
Vickers (solid injection) ..	4	1,250	6	24·5	39	118	76	765	—	36 6
Werkspoor	4	1,250	6	23	41	125	77	855	137	32 0
Sulzer	2	1,250	4	23·6	37	102	76·3	648	168	31 6
Sulzer (turbo scav. pumps) ..	2	1,250	4	—	—	125	—	—	115	—
Ansaldo San Giorgio	2	1,250	4	24·8	35·4	110	66	678	—	30 0
Camellaird-Fullagar	2	1,250	4	18·5	26	125	71	540	112	21 6

TABLE III.—SAVINGS WHICH CAN BE EFFECTED BY ALTERING THE DIMENSIONS OF THE SHIP AS A RESULT OF THE DECREASE IN MACHINERY WEIGHT.

M.S. Peru.	With Burmeister and Wain Engines.	As altered to suit:			
		Sulzer Engines.		Camellaird-Fullagar Engines.	
		First Alternative.	Second Alternative.	First Alternative.	Second Alternative.
S.H.P.	2,500	2,480	2,460	2,475	2,450
Speed, knots	11·15	11·15	11·15	11·15	11·15
Length B.P.	425·5 ft.	425·5 ft.	429 ft.	425·5 ft.	430 ft.
Beam	55 ft.	54·65 ft.	55 ft.	54·6 ft.	55 ft.
Depth to shelter deck	38·5 ft.	38·3 ft.	38·5 ft.	38·25 ft.	38·5 ft.
Draught loaded	28 ft.	27 ft. 10 in.	28 ft.	27 ft. 9 in.	28 ft.
Block coefficient	·716	·716	·7025	·716	·70
Displacement, tons	13,400	13,210	13,250	13,160	13,210
D.W.T. capacity, tons	9,400	9,400	9,400	9,400	9,400
Gross tonnage	6,919	6,825	6,840	6,805	6,840
Net tonnage	5,223	5,155	5,160	5,140	5,160
Reduction in steel weight, tons	—	40	0	50	0
Fuel consumption, pounds B.H.P. hour	0·40	0·406	0·406	0·40	0·40
Fuel, tons per 24 hours	10·7	10·8	10·7	10·6	10·5
Per cent. difference in fuel consumption ..	—	0·94 increase	Nil	0·94 decrease	1·87 decrease
Per cent. decrease in rates and dues based on net tonnage	—	1·3	1·2	1·6	1·2

TABLE V.—SHOWING INCREASE IN CARGO CAPACITY WITH TWO-CYCLE ENGINES.

Engines.	Burmeister and Wain.	Sulzer.		Camellaird-Fullagar.	
		First Alternative.	Second Alternative.	First Alternative.	Second Alternative.
Gross tonnage	6,919	6,825	6,840	6,805	6,840
Engine-room cubic feet = 13 per cent. of gross tonnage	90,000	88,600	89,000	88,500	89,000
Saving, cubic feet	—	1,400	1,000	1,500	1,000
Cubic cargo capacity, cubic feet (grain) ..	548,450	549,850	549,450	549,950	549,450
Cubic feet per D.W.T. ton	58·4	58·5	58·45	58·55	58·45

TABLE II.—*Comparison of Weights of Machinery, and the advantages gained by the adoption of Two-cycle Engines.*

Engines.	Burmeister and Wain.	Sulzer (turbo scav.).	Camellaird-Fullagar.
S.H.P.	2,500	2,500	2,500
Weight of two main engines, tons	384	230	224
Weight of two intermediate shafts, tons	39·2	33	35
Weight of Diesel dynamo sets, tons	33	60	29
Total weight, tons ..	456·2	323	288
Increase in D.W.T. capacity of ship, tons	—	133·2	168·2
Increase in D.W.T. capacity, per cent.	—	1·42	1·79
Fuel consumption, pounds per B.H.P. per hour ..	·40	·406	·40
Fuel consumption, tons per 24 hours	10·7	10·87	10·7
Increase in fuel consumption, per cent.	—	1·6	Nil

TABLE IV.—*Advantages of Two-cycle Engines with Reduced Revolutions per Minute.*

Engines.	Burmeister and Wain.	Sulzer.	Camellaird-Fullagar.
Total S.H.P.	2,500	2,350	2,350
Total R.P.M.	125	90	90
Weight of two main engines, tons	384	315	288
Weight of two intermediate shafts, tons	39·2	37·4	41·3
Weight of Diesel generating sets, tons	33	60	29
Total weight, tons ..	456·2	412·4	358·3
Increase in D.W.T. capacity, tons	—	43·8	97·9
Increase in D.W.T. capacity, per cent.	—	·47	1·0
Fuel consumption, pounds B.H.P. hour	·40	·406	·40
Fuel, tons—24 hours ..	10·7	10·20	10·06
Reduction in fuel consumption, per cent.	—	4·67	6·0

Burmeister and Wain engined ship. In the second alternative the length of the ship is increased, the beam, depth and draught are unaltered, while the block coefficient is reduced, thus making a finer ship. The author is indebted to Mr. C. Frodsham Holt for the calculations of ship dimensions and power required in each case.

In a ship of this size and speed, the tonnage dues over a year's working may amount to from 0·6 to 0·86 of the total fuel cost for the year, depending on the ports of call and the price of oil.

A still greater advantage can be gained by the installation of two-cycle engines running at a reduced speed, say, 90 r.p.m., instead of 125 r.p.m., as with Burmeister and Wain engines, on account of the higher propeller efficiency attained at the lower speed. If the ship required 2,500 s.h.p. to give her 11 knots at 125 r.p.m., then at 90 r.p.m. only about 2,350 s.h.p. will be required, a reduction of 6 per cent. The machinery weights will now be as in Table IV. The present Burmeister and Wain engines running at 125 r.p.m. could be replaced by larger Burmeister and Wain engines running at 90 r.p.m., but there would be an increase in machinery weight of from 120 to 150 tons, involving an increase in the size of the ship and the power required to attain the same speed, the deadweight carrying capacity of the ship remaining the same. The Camellaird-Fullagar engines, on the other hand, give to the ship an increased deadweight carrying capacity of about 100 tons, and at the same time the fuel consumption is reduced by 6 per cent., due to the smaller power required. As an alternative to increasing the deadweight tonnage of the vessel, advantage can be taken of the reduction in machinery weight of 100 tons by slightly altering the design of the ship, in which case the shaft horse-power and the fuel consumption would be still further reduced.

Space Occupied.—The existing engine room of the M.S. Peru is equivalent to about 13 per cent. of the gross tonnage of the vessel, and is, therefore, at the lower limit as regards size. Shipowners are unwilling to accept an engine room below this figure on account of the existing regulations governing the calculation of the net tonnage on which the dock and harbour dues are based. Table V. gives the minimum cubic capacity of the engine rooms with the various types of engine, taking the engine room at 13 per cent. of the gross tonnage in each case. It will therefore be seen that in the matter of space occupied in this type of ship there is no appreciable advantage to be obtained by the substitution of two-cycle for four-cycle engines so long as the present tonnage regulations are in force.

Fuel Consumption.—It is necessary to point out that the fuel consumption in two-stroke cycle gas engines and petrol engines is greater than in four-cycle engines, owing to some of the fuel going direct to exhaust during the charging period. Such loss as this cannot occur in the two-cycle engine when the fuel is not admitted until after compression of the charge of air. Recent developments in connection with two-cycle engines have enabled them to work with as small fuel consumption as four-cycle engines, and it is probable that, as further experience is gained with two-cycle engines, the fuel consumption in these will be appreciably less than in four-cycle engines.

Cost of Machinery.—The cost of an engine depends largely on the weight of materials and the amount of workmanship involved. The two-stroke cycle engine, having usually only four cylinders as against six in the four-cycle engine, and having no suction and exhaust valves, is very much simpler than the four-stroke cycle engine, and the percentage reduction in cost should, therefore, be nearly proportional to the percentage reduction in weight. The cost of an engine is also largely influenced by the degree of standardisation and the number of engines of the same type turned out, and, therefore, the two-cycle engine has not yet realised its full advantage. The cost of auxiliaries bears a considerable proportion of the total cost of machinery in a motorship, and these auxiliaries, being approximately the same with both types of engine, the saving in the total cost of the machinery installation is not in proportion to the reduction in the weight of the main engines.

Mechanical and Structural Considerations: Cylinder Liners.—Advocates of the four-cycle engine frequently point to the cylinder liner as being the weak point of the two-cycle engine, and it is sometimes stated that the stresses in these liners are nearly twice as great as in the four-cycle engine.

In an article on "Temperature Stresses in Large Diesel Engine Liners," in the October, 1920, issue of the *Motor Ship*, Mr. H. F. P. Purday arrived at the conclusion that in four-cycle and two-cycle engine cylinders of equal diameter the "equivalent static stress" in the cylinder liner of the latter is 40 per cent. higher than in the former, owing to the higher heat stresses involved. It must be remembered, however, that the two-cycle engine cylinder gives, on an average, 71 per cent. more power than the four-cycle engine cylinder. In four-cycle and two-cycle engine cylinders of equal power, taking the piston speed as 660 ft. per min. and 600 ft. per min., and the brake mean pressures as 72 and 69 lb. per sq. in. respectively, the "equivalent static stress" will be about 22 per cent. higher in the two-cycle engine than in the four-cycle engine, according to Mr. Purday's calculation, if the thickness of the liner is such as to give the least stress in each case.

Cylinder Covers.—The mean temperature of the gases in the cylinder of the two-cycle engine being higher than in the four-cycle engine, it might be expected that the heat stresses in the cylinder covers would be greater in this type of engine. It must be remembered, however, that the four-cycle engine cylinder cover contains four or five valve pockets, involving an exceedingly complicated casting, as compared with the smaller cover, with only one or two pockets, of the two-cycle cylinder. The heat stresses are probably less in the two-cycle engine cover, and less trouble has been experienced with covers in two-cycle engines of the port scavenging type than in four-cycle engines. All cylinder cover difficulties are, of course, eliminated in the case of the opposed piston engine.

Pistons.—In the issue of the *Motor Ship* for April, 1922 Mr. H. Blache states, as an advantage of the four-cycle, engine, that the piston rings can be placed some distance below the heated top of the piston, whereas, in the two-cycle engine, where the piston is used as a slide valve, the rings must be kept near the top of the piston, being thus exposed to a higher temperature. It may be pointed out, however, that in the Doxford engine the first piston ring is about 6 in. from the head of the piston, and it would appear, therefore, that no trouble is experienced due to leakage past the piston crown after the first ring has uncovered the ports. This removes the foundation of this objection, and the arrangement can be applied to the pistons of other two-cycle engines if it is found to be necessary.

Lubrication.—The lubrication of the four-cycle cylinder liner and piston is better than in the two-cycle engine, in which the liner wall is pierced by scavenge and exhaust ports, but advocates of the four-cycle engine lay undue stress on this point, as no difficulty is experienced in the efficient lubrication of two-cycle engine cylinders. In the two-cycle engine a small proportion of the lubricating oil is lost through the exhaust ports, but as the lubricating oil consumption is about the same as in four-cycle engines of the same power, it is evident that this loss is negligible. As regards the lubrication of crank pins and main bearings, the four-cycle engine is superior to the single piston two-cycle engines, these having no reversal of load on the bearings to promote efficient lubrication.

The long piston skirt in two-cycle engines, which takes the place of the piston rod, projects into the crank case, allowing the oil refuse to mix with the clean lubricating oil. The actual quantity of refuse dripping into the crank case is small compared with the amount of oil in circulation, and as the oil from the crank case is strained and cleaned before being returned to the engine bearings, it is an open question as to whether in practice this point is of any importance.

Valves.—In the four-cycle engine the exhaust valves are a continual source of trouble. These valves are usually built with a separate removable seat of special material. Even under the best conditions, when using good Diesel engine oil, the suction and exhaust valves require grinding-in frequently, and in a twin-screw ship with six-cylinder engines the grinding-in of twenty-four

valves entails considerable labour on the part of the engine-room staff.

The Ability to Use Boiler Fuel Oil.—Diesel engines have been operated up to the present time almost entirely on special grades of fuel oil, which cost about 20 per cent. more than boiler fuel oils, and are less easily obtainable. It is a matter of great importance to develop the Diesel engine so that it may satisfactorily use all grades of boiler fuel oil. The two-cycle engine is more adapted to the use of this oil, owing to the absence of exhaust valves in these engines.

Piston Cooling.—In the four-cycle engine all telescopic tube glands and water connections can be conveniently kept outside the crank case, the cylinder being raised above the top of the latter. In the two-cycle engine some or all of the piston cooling pipes and telescopic tubes are inside the crank case, but leakage from the glands can be collected and drained out of the crank case without danger of water getting into the lubricating oil, this being merely a matter of design.

Crankshafts.—There are critics of the use of solid crankshafts in two-cycle engines. They state that a built-up shaft is better able to withstand distortion of the engine due to hogging and sagging of the ship. Two-cycle engines, however, frequently use built-up shafts, and in any case the necessity for flexibility of the crank-shaft is not so marked in the case of the shorter two-cycle engine, and especially in the case of the opposed piston engine, which is little more than half the length of the four-cycle engine for the same power. When a solid crankshaft is forged in a hydraulic press and not by means of a steam hammer, the steel should be as sound even in the webs as in the parts of a built crankshaft.

Balancing.—It has been frequently stated that the four-cycle engine with six cylinders is better balanced than the two-cycle engine with four cylinders. It must be remembered, however, that in the latter engine the reciprocating parts are smaller and lighter than in the four-cycle engine. There is little to choose between the two engines in the matter of balance. The four-cylinder two-cycle engine has, on the other hand, a very much more even turning moment.

Complication.—The two-cycle engine has usually only four cylinders as compared with six in the four-cycle engine, and the twelve suction and exhaust valves with their operating gear are entirely eliminated. On the other hand, the two-cycle engine requires the addition of a scavenge pump.

Piston Rings.—The fact that the piston rings have to pass over the exhaust and suction ports is sometimes put forward as a disadvantage of the two-cycle engine, but if proper care is taken in the design of the ports and rings, and the method of pegging the latter, no trouble is experienced.

General Conclusions.—A careful consideration of the points which have been discussed above leads to the conclusion that the mechanical and structural advantages and disadvantages of the four-cycle and the two-cycle engine are at present fairly evenly balanced between the two types. There is no reason, therefore, why the two-cycle engine should be less reliable than the four-cycle engine, which is confirmed by a study of the records of voyages of modern two-cycle engined ships. This being the case, the question of which is the best type of engine to adopt depends on the fundamental considerations discussed earlier in the present paper. On these points the two-cycle engine shows a marked advantage over the four-cycle engine, and this advantage will be greatly increased with increased experience and when the existing tonnage regulations are revised.

THE PHYSICAL SOCIETY.

A MEETING of the Physical Society was held on December 8, 1922, at the Imperial College of Science, Kensington, Dr. Alexander Russell, M.A., in the chair. Three papers were read and discussed.

1. "*The Relation between Molecular and Crystal Symmetry as shown by X-Ray Crystal Analysis.*" This paper was read by Mr. G. Shearer, M.A., B.Sc. It pointed out that the methods of X-ray analysis enabled the number of molecules associated with the unit cell to be determined. With the help of this information an attempt was made to connect the symmetry properties of the crystal with this number and with the symmetry properties of the molecules from which the crystal is formed. The symmetry number of each of the 32 crystal classes was given, and was shown to mean the minimum number of asymmetric molecules necessary in the unit cell to satisfy the symmetry conditions. The relative orientations and positions of these molecules in the cell were discussed. It was suggested that this symmetry number was the actual number of molecules in the cell when the molecule was asymmetric; further that, if the molecule possessed symmetry, this symmetry appeared also in the crystal, and the number of molecules in the unit cell was obtained by dividing the symmetry number of the crystal by the symmetry number of the molecule. Evidence was produced in support of these hypotheses and examples were given of their application to inorganic and organic crystals.

Discussion.—Sir William Bragg said that the paper before the meeting was an important one, throwing a new light on the possibilities of investigating crystal structure. The author's intricate but lucid argument afforded a great simplification of the problem. Three unitary structures had to be considered: (1) The chemical molecule, as it existed in solution; (2) the elementary crystal lattice or cell, consisting of groups of (3) crystal molecules, in which the atoms and electrons were not necessarily arranged in the same manner as in chemical molecules. The author's method enabled one to determine the symmetry of these groups at once from the geometry of the crystal, with a very little help from X-rays. A considerable vista of research was thus opened up, which might serve to settle such questions as that of the static *versus* the dynamic model of the atom.

Dr. J. W. Evans thought that the methods employed by Mr. Shearer gave promise of proving of great assistance in working out the structure of crystals. There were, however, some considerations that must not be neglected: (1) It was by no means certain that molecules always maintained their identity in the crystalline state. (2) Even where they existed in the crystal, they might not retain the same form and symmetry as in a free state. (3) Although in an ideal crystal all the cells were identical, and had identical orientation, this was by no means always actually true. We knew that cells of different composition might be employed indiscriminately if they were approximately the same in form and volume, as in the case of the plagioclase felspars.

In the same way, if the outer forms of cells of the same substance approximated to a higher symmetry than the cell itself, these cells might, even when differently orientated, be employed in building up a crystal structure. The same might be true with cells that were enantiomorphically related. In these cases the whole structure might have a higher symmetry than the individual cells as the result of either (*a*) a symmetrical arrangement of the cells in the nature of molecular or ultramicroscopic twinning—twinning was usually an attempt to attain higher symmetry—thus forming lattice cells of greater size; or (*b*) indiscriminate occurrence of cells differing in orientation or in enantiomorphic character. In the former case it might be very difficult to recognise by means of X-ray analysis the primary cells. In the latter case it would, he thought, be impossible.

The explanation of the crystalline structure of potassium chloride was not convincing. He threw out the suggestion that crystal structure might possibly be due to the repulsion of the electrons of different atoms combined with an attraction of the atoms as a whole. If it be supposed that, contrary to the usual view, there were six outer electrons in chlorine having their mean position arranged like the points of an octahedron, and that in potassium there were eight electrons arranged like the points of a cube, it would be evident that a position of stability would be obtained when the points of each chlorine octahedron were opposite the centres of faces of the surrounding potassium cubes and the points of each potassium cube were opposite the centre of a face of a chlorine octahedron, and that the potassiums and chlorines would then be arranged alternately in a cubic lattice just as we knew to be the case.

2. "*Modification of the Power Method of Determining the Structure of Metal Crystals.*" A paper on this subject was next read by Dr. E. A. Owen, M.A., and Mr. G. D. Preston, B.A. It stated that plates of aluminium, iron, copper, lead and magnesium had been examined by means of the Bragg X-ray spectrometer, employing radiation direct from a molybdenum anti-cathode. The maxima observed in the spectra were sufficiently intense to measure with accuracy, and the crystalline structure of the materials examined were readily determined. A few of the results obtained by the method were included in the paper as typical examples.

Discussion.—Sir William Bragg said the authors' work indicated that the technique of crystal analysis was improving and that its methods were coming into general use. A consideration to be borne in mind was that one of the crystal planes might become unduly accentuated by the polishing process. Further, in the case of aluminium and other metals it was possible for individual crystals to be very large.

Dr. G. D. West, after dwelling on the advantages of focussing the X-ray beam by inclining the plane in which the crystals lie, inquired as to the width of the slits employed as the conditions varied, and as to the allowance to be made for variations in the output of the bulb.

Mr. Preston, in reply, stated that the authors had been careful to use crystals less than 1 mm. in size. The chamber slit was kept at 2 mm., and the bulb slit varied from 2 mm. to 4 mm. for different parts of the spectrum. The output of the bulb could be kept constant by regulating the filament current, but for moderate accuracy little regulation was required.

3. "*The Cathode Ray Oscillograph.*" The next paper was by Dr. A. B. Wood. It was read by Captain C. S. Wright. This paper dealt with a new form of cathode-ray oscillograph adapted for commercial production and laboratory use. The instrument described was of the low-voltage type, in which a hot cathode was employed as a source of the electron current. This low-voltage type of oscillograph was much more sensitive than the high-voltage cold-cathode type designed by M. Dufour. Various methods were described for focussing the cathode-ray stream, and a proposal had been made for an oscillograph with external (*i.e.*, outside the vacuum) photographic film. Experiments had been made to determine the most suitable photographic film or plate. Ordinary gelatine-coated roll films or plates were unsuitable, owing to the marked absorption of the cathode rays by the gelatine. The best results had been obtained with Schumann plates containing a proportion of calcium tungstate. This material phosphoresced with a light rich in ultra-violet, and consequently the secondary luminous effect on the Schaumann plate was very great.

Mechanical, electrostatic and electromagnetic methods were described for generating a time-axis on the records. For certain purposes this time axis was sinusoidal, whilst for others it was linear. Numerous records of high-frequency alternating-current wave forms and of impulsive electrical phenomena had been obtained, and a few of these were reproduced in the paper. Brief reference was made in conclusion to the applications of the oscillograph to research and electrical engineering problems, where other well-known forms of oscillograph (Duddell, Einthoven, &c., types) cannot be employed on account of the inertia of the moving element.

Discussion.—Mr. Mines inquired whether any measurement had been made of the potential gradient in the tube with a view to determining the distribution of potential along the path of the rays. Was anything known of the current density of the rays, and was there (as in the arc lamp) a limiting value to such current density, involving a maximum intensity for the spot of light beyond which it would be impossible to go? Had the author tried the focussing effect of charging the cylindrical shield to a positive potential of, say, 100 volts?

Mr. R. A. Watson Watt joined in the appreciation of Dr. Wood's lucid account of a most important and valuable instrument of research. Perhaps the most outstanding feature of his work was the way in which the oscillograph had been converted into a robust engineering structure, which the "glass shy" engineer could approach with more confidence than he felt towards the older forms of blown glass tube, and into an instrument with a much higher expectation of life than these older forms possessed.

In considering cathode-ray oscillations in general, one should not lose sight of the fact that there was a wide field of application for sensitive tubes in which it was not necessary to resort to photography with its attendant difficulties and complications. Single axis working, in which the tube was valuable as a direct reading high-frequency voltmeter, was in itself sufficient justification for such tubes. But Dufour had shown that in wave form work one could obtain visual images of radio frequency wave forms from his high-voltage tubes, while recently, by the courtesy of the International Western Electric Company he (Mr. Watt) had been able to satisfy himself that a reliable visual image of a transient deflection of 10^{-4} seconds duration could be obtained with the 300-volt beam of their tube. The fluorescent spot had a translational speed of about 5×10^{-4} cm. per second in this experiment. This, whether due to persistence of vision or to persistence of fluorescence, was much more satisfactory than one had the right, *a priori*, to expect.

He would be grateful if Dr. Wood could say whether any data were available as to a tube working on the 100 volts, which he mentioned as a lower limit. A tube of this extreme sensitivity would be most valuable, but he knew of no references to a stably operating tube with an accelerating voltage below 300 volts. Finally, he would like to ask the author whether he had any experience of Van der Bijl's "positive ion" method of focussing, as used in the Western Electric tube. It appeared to be a method of great value, particularly in view of the fact that the commonly-used electromagnetic "paralleling" method reduced the sensitivity of the tube. His experience of low-voltage tubes lead him to conclude that at the present moment the limitation of sensitivity for visual observation lay not in the mechanism of beam production or concentration, but in the fluorescent materials used for the screen, and that progress in that direction could still be made.

Mr. R. S. Whipple said that the instrument described would meet a real demand, as oscillographs using a cold cathode were cumbersome and costly, while the one under discussion should be within the means of most laboratories. The method of phosphorescent sensitisation opened up great possibilities.

4. *Demonstration.*—A demonstration of a low-voltage cathode-ray oscillograph was given by Mr. R. Webb, of the International Western Electric Company. This instrument, which is designed to work at 300 volts, is intended for manufacture on a commercial basis. The cathode consists of a hot platinum filament coated with certain oxides, and formed into a circle coaxial with the path of the rays. It is protected from bombardment by positive rays, which would disintegrate it, by a screen in which is cut a circular hole slightly less in diameter than the filament. It has a life of about 200 hours. The anode is a platinum tube through which the rays pass. The deflecting fields are electrostatic, and are provided by two pairs of plates at right angles. The bulb is in the form of a conical flask, the cathode being at the narrow end so that the rays impinge on the flat bottom which is coated inside with fluorescent matter. The luminous trace of the rays can be seen from outside through the bottom of the flask. The apparatus was connected up to show the characteristic of an oscillation generating valve, so that the potential difference between one pair of plates was proportional to the grid potential, and that between the other pair to the plate current. The resulting trace consisted of a single curved line terminating in a loop of peculiar form at one end.

EXAMINATION OF ENGINEERS.—The Board of Trade have decided, with a view to economy and efficiency in the conduct of the examinations of engineers, to hold them at a smaller number of ports than hitherto. On and after February 1, 1923, examinations will no longer be held at Greenock, West Hartlepool, Bristol and Londonderry, but additional examinations will be held at Glasgow. At Cardiff, examinations will be held in the fourth and fifth weeks of the month; at Hull and Leith, examinations will be held monthly, and the times of the examinations at Dundee will be altered. The ports and times at which examinations will be held will be as follows: Aberdeen: Third Tuesday in each month. Belfast: Fourth Tuesday in each month. Cardiff: Fourth and Fifth Tuesday in the month. Dublin: First Tuesday in each month so long as arranged by the Board of Trade on behalf of the Irish Free State Government. Dundee: Fourth Tuesday in each month. Glasgow: Tuesday in each week. Hull: First Tuesday in each month. Leith: Second Tuesday in each month. Liverpool: Tuesday in each week. London: Tuesday in each week. North Shields: Tuesday in each week. Southampton: Second Tuesday in each month. Sunderland: Third Tuesday each month.